THE

KANSAS UNIVERSITY

SCIENCE BULLETIN

DEVOTED TO

THE PUBLICATION OF THE RESULTS OF
RESEARCH BY MEMBERS OF THE
UNIVERSITY OF KANSAS

Vol. XIV

ENTOMOLOGY NUMBER V.

PUBLISHED BY THE UNIVERSITY,
LAWRENCE, KANSAS.
1922.
9-4522

CONTENTS OF VOLUME XIV.

THE

KANSAS UNIVERSITY SCIENCE BULLETIN

VOL. XIV, No. 1—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 1.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 1.

Historical Account of Department of Entomology.

(Continued from SCIENCE BULLETIN VIII),

Brief résumé of the work of the Department of Entomology of the University of Kansas during the past quarter century.

BY H. B. HUNGERFORD.

ENTOMOLOGICAL work has been in progress at the University of Kansas since the foundation of the institution in 1866. The first faculty consisted of three men, one of whom was Dr. Francis Huntington Snow, professor of mathematics and natural science.

Doctor Snow, while widely interested in birds and flowers, gave early evidence of a special fondness for the study of insects. Through his efforts, and those of others who have followed him, there has been established what is perhaps the greatest general collection of insects to be found in connection with any state university in America.

In 1890 Doctor Snow became chancellor of the University, and Dr. Vernon L. Kellogg was appointed to the entomology work, first as assistant professor of entomology, and later as associate professor.

Doctor Kellogg was called to Stanford University in 1894, and for the year 1895 the entomological work was in charge of W. A. Snow, son of the chancellor.

In 1896 Prof. S. J. Hunter was appointed assistant professor of entomology and placed in charge of the department, and for the past quarter of a century he has directed his energies toward the development of a department that should rank among the strongest in the country. During this span of years the department has trained many students and grown remarkably in its material equipment, both through the greatly enriched entomological collections and its mechanical facilities for furthering research and advancing instruction in entomology.

The teaching staff has increased from one to five, and the student roll, from a few to more than 250. A total of 2,000 pages, under 276 titles, have been published by members of the department, and twenty-three scientific expeditions of the entomological museum have been made during the past twenty-five years. These accomplishments, together with the various economic state problems that have arisen from time to time, indicate an active and productive period in the history of the department.

In 1914, SCIENCE BULLETIN issued its second entomological number. This was dedicated to Doctor Snow, and in it may be found a chronological account of the activities of the department up to and including the year 1913. As a matter of record, additions are made below to the various sections as they have occurred since that year.

CHRONOLOGICAL REVIEW OF EVENTS SINCE 1913.

1913. Mr. George Collett appointed Fellow in Entomology.

F. X. Williams, who received his M. A. degree in this department in 1913, resigns to study for the doctorate at Harvard.

Professor Hunter, Assistant Professor Hungerford, Mr. George Vansell and Mr. George Collett conduct a biological survey in Wyoming, Utah and Montana with special reference to distribution and biology of grasshoppers of Kansas.

1914. P. W. Claassen becomes assistant state entomologist.

Raymond Beamer becomes assistant curator of museum.

Professor Hunter, Assistant Professor Hungerford, Raymond Beamer, Will Brown and Fred Poos collect along the Rio Grande in southwestern Colorado.

1915. Walter Wellhouse elected fellow in entomology.

Mr. Raymond Beamer, B. P. Young, Forrest Anderson and Walter Wellhouse make an entomological survey of the counties of southeastern Kansas.

B. P. Young takes charge of the insectary.

1916. Forrest Anderson elected fellow in entomology.

Professor Hunter takes a four months' leave of absence.

H. B. Hungerford appointed temporary chairman and acting state entomologist.

Hungerford, Lawson and Wellhouse go to Wellington, Kan., to investigate green-bug outbreak. The Federal Bureau, the Kansas Agricultural College and the University combine to study the green bug and methods of control. Lawson and Wellhouse represent the University for several weeks in this work.

Mr. Raymond Beamer, with Grutzmacher, Darby and Gardner, make an entomological survey of some southern Kansas counties.

H. B. Hungerford is granted a year's leave of absence to study for the doctorate at Cornell University.

P. W. Claassen takes Mr. Hungerford's place for the year.

P. B. Lawson becomes assistant instructor.

1917. H. B. Hungerford made associate professor of entomology.

P. B. Lawson made instructor in entomology.

Ruby Hosford takes charge of insectary.

Dr. C. P. Alexander becomes assistant curator of entomological museum.

Miss Eva Batchman appointed assistant instructor.

William Hoffmann elected fellow in entomology.

Doctor Alexander conducts a party, consisting of Harry Fackler, William Hoffmann and Scott Johnson, on an entomological survey of southwestern Kansas.

Canker-worm work in cities of eastern Kansas conducted by Professor Hunter.

1918. Entire University reorganized to handle S. A. T. C. Department of entomology teaches three sections of biology. Miss Weaverling takes charge of insectary.

1919. William Hoffmann is appointed assistant in charge of insectary.

P. B. Lawson granted degree of doctor of philosophy by Kansas University; major, insect taxonomy; first minor, insect morphology; second minor, systematic botany. Title major thesis, "Cicadellidæ of Kansas."

Miss Itasca Hilsman elected Fellow in Entomology.

1920. H. B. Hungerford made Professor of Entomology.

P. B. Lawson becomes Assistant Professor of Entomology.

Mr. William Hoffmann transferred from the insectary to assistant curator of museum.

Mr. Philip A. Readio is appointed instructor in entomology.

Miss Lucy Hackman becomes assistant instructor.

Miss Itasca Hilsman reappointed fellow in entomology.

1921. Mr. Lawson becomes associate professor of entomology.

W. J. Brown becomes student assistant in the museum.

W. J. Brown, Jean Linsdale and Robert Guentert continue the biological survey in northeastern Kansas.

P. B. Lawson and Raymond Beamer devote some time to the study of the destructive outbreak of pea aphis in first-crop alfalfa.

1922. Miss Kathleen Doering appointed fellow in entomology.

P. B. Lawson becomes professor of entomology and assistant dean of the College of Liberal Arts and Science.

Miss Kathleen Doering appointed scientific illustrator.

C. Howard Curran, of Orillia, Canada, appointed research fellow in entomology.

R. H. Beamer reappointed assistant curator of the entomological collections.

ENTOMOLOGICAL PAPERS FROM UNIVERSITY OF KANSAS.

(Continued from SCIENCE BULLETIN VIII.)

ALEXANDER, C. P.

No. Date. Title of paper.

203. 1918—Records of Japanese Crane Flies (Diptera). Am. Ent. Soc. Amer., vol. XI, pp. 443-449.

204. 1918—New Species of Tipuline Crane Flies from Eastern Asia (Tipulidæ, Diptera). Jour. N. Y. Ent. Soc. vol. XXVI. pp. 66-75.

205. 1918—A New Interpretation of the Wing Venation of the Pedicine Crane Flies (Tipulidæ, Diptera). Ent. News, vol. XXIX, pp. 201-205.

206. 1918—New Species of Crane Flies from California (Diptera). Ent. News, vol. XXIX, pp. 285-288.

207. 1918—New Nearctic Crane Flies (Tipulidæ, Diptera), Part IV. Can. Ent., vol. L, pp. 60-71.

208. 1918—New Nearctic Crane Flies (Tipulidæ, Diptera), Part V. Can. Ent., vol. L, pp. 158-165, 242-246.

209. 1918—New Nearctic Crane Flies (Tipulidæ, Diptera), Part VI. Can. Ent., vol. L, pp. 381-386, 411-416.

210. 1919—The Crane Flies Collected by the Canadian Arctic Expedition, 1913-'18, Report of the Canadian Arctic Expedition, 1913-'18, vol. III, part C, pp. 1C to 30C.

211. 1919—Notes on the Genus *Dicranoptycha* Osten Sacken. Ent. News, vol. XXX, pp. 19-22.

212. 1919—New or Little-known Crane Flies from Japan, Part 1. The Entomological Magazine, Kyoto, Japan, vol. III, pp. 122-127.

213. 1919—The Biology of the North American Crane Flies (Tipulidæ, Diptera), Part V. Pomona College Jour. Ent. and Zoöl., vol. XI. pp. 67-74.

BEYER, ADOLPH.

214. 1922—A Brief Résumé of Investigations Made in 1913 on *Trogoderma inclusa*. Science Bulletin, vol. XIV (this number).

BEAMER, RAYMOND H.

215. 1916—An Easy Method of Making Insect Labels Ent News, vol. XXVIII, p. 418.

216. 1917—The Oedipodinæ of Kansas. Bul. of the Dept. of Ent., University of Kansas, No. 11, pp 51-126; 74 text figures.

CLAASSEN, P. W.

217. 1914—Grasshopper Control in the Southern Division of Kansas (with Professor Hunter). Jour. Ec. Ent., vol. VII, No. 1, pp. 73-81.

218. 1917—The Melanopli of Kansas. Bul. of the Dept. of Ent., University of Kansas, No 11, pp. 5-50; 5 figures.

CURRAN, C. HOWARD.

219. 1922—On the Nemestrinid Genus *Rhyncocephalus* (Nemestrinidæ, Diptera), Can. Ent., vol. LIV.

220. 1922—Diptera in the Collection of Miss Frances Long (supplement to paper by Miss Frances Long on Plant Pollination in Insects). (In press.)

DOERING, KATHLEEN.

221. 1922—Biology and Morphology of *Lepyronia quadrangularis* (Say). Science Bulletin, vol. XIV (this number).

EMERY, W. T.

222. 1914—Morphology and Biology of *Simulium vittatum* and its Distribution in Kansas. Science Bulletin VIII; 15 plates.

HACKMAN, LUCY.

223. 1922—Studies in *Cicadella hieroglyphica*. Science Bulletin, vol. XIV (this number); 5 plates.

HUNGERFORD, H. B.

224. 1914—Anatomy of *Simulium vittatum*. Science Bulletin, vol. VIII, pp. 365-382; 3 plates.
225. 1914—Notes on Coleoptera from Western Kansas (with F. X. Williams). Ent. News, vol. XXV, pp. 1-9; 2 plates.
226. 1915—A Parasite of Cottonwood Borer Beetle. Ent. News, vol. XXVI, p. 135.
227 1916—Sciara Maggots Injurious to Potted Plants. Jour. Ec. Ent, vol. IX, pp. 538-549; 2 plates.
228. 1917—Brief Laboratory Outline for Introductory Entomology State Printer; 18 pages.
229. 1917—Egg-laying Habits of a Back Swimmer, *Buenoa margaritacea* Bueno. Ent. News, vol. XXVIII, pp. 174-183; 1 plate.
230. 1917—Notes Concerning Food Supply of Some Water Bugs. Science N S., XLV, pp. 336-337.
231. 1917—Food Habits of Corixids. Jour. N. Y. Ent. Soc., vol. XXV, pp. 1-5; 1 plate.
232. 1917—The Life History of a Back Swimmer, *Notonecta undulata* Say. Ent. News, vol. XXVIII, pp. 267-278, 2 plates.
233. 1917—The Life History of *Mesovelia mulsanti* White Psyche, vol. XXIV, pp. 73-84; 1 plate.
234. 1917—The Life History of a Boatman. Jour. N. Y. Ent. Soc., vol. XXV, pp 112-122; 1 plate
235. 1918—Notes on the Oviposition of Some Semiaquatic Hemiptera. Jour. N. Y. Ent. Soc., vol. XXVI, pp. 12-18; 1 plate.
236. 1918—Concerning the Oviposition of the *Notonecta*. Ent. News, vol. XIX, pp. 241-243; 1 plate.
237. 1919—Biology and Ecology of Aquatic and Semiaquatic Hemiptera. Science Bulletin, vol. XI, pp. 3-328, 33 plates.
238. 1919—Male Genitalia as Characters of Specific Value in Certain Cryptocerata. Science Bulletin, vol. XI, pp. 329-332; 2 plates.
239. 1919—Biological Notes on *Tetradonema plicans* Cobb, a Nematode Parasite of *Sciara coprophila* Lint. Jour. of Parasitology, vol. V, pp. 176-192; 1 plate, 3 text figures.
240. 1919—Tables for Determining Types and Breeds of Domesticated Animals (third edition). Comstock Publishing Co., Ithaca, N. Y.; 38 pp., 3 plates.

241. 1920—Laboratory Outline for Course in Introductory Entomology (revised and enlarged). World Publishing Co.; 39 pp.
242. 1922—Life History of the Toad Bug, *Gelastocorus oculatus* Fabr. Science Bulletin, vol. XIV; 2 plates (this number).
243. 1922—A new Subterranean Isopod from Kansas. Science Bulletin, vol. XIV; 1 plate (this number).
244. 1922—A Review of the Past Quarter Century of Entomology in Kansas University. Science Bulletin, vol. XIV (this number).
245. 1922—The Nepidæ of North America. Science Bulletin, vol. XIV; 8 plates (this number).
246. 1922—Oxyhæmoglobin Present in the Back Swimmer, *Buenoa margaritacea* Bueno. Can. Ent., vol. LIV.
247. 1922—*Saldoidea slossoni*, new var. *uhleyii*. Bul. Brooklyn Ent. Soc., vol. XVII, page 64 (Apr.).
248. 1922—Notable Additions to Entomological Library at Kansas University. Bul. Brooklyn Ent. Soc. (Accepted for publication.)
249. 1922—Both Hydrometras in Kansas. Bul. Brooklyn Ent. Soc., vol. XVII, p. 78 (June).
250. 1922—Water Insects from a Portion of the Southern Utah Desert (with Dr. R. C. Moore). Science Bulletin, vol. XIV (this number).
251. 1922—Some Notes on the Egg-laying Habits of the Corixidæ. Bul. Brooklyn Ent. Soc. (In press.)
252. 1922—A Study of the Hydrometra of America North of Mexico, with Description of a New Species (Heteroptera, Hydrometridæ). Can. Ent., vol. LV. (In press.)

HUNTER, S. J.

253. 1914—University Experiments with Sand Fly and Pellagra. Science Bulletin, vol. VIII.
254. 1914—Control Measures for the Native Grasshoppers and Chinch Bugs. Bien. Rep. St. Bd. Ag., vol. XXIV, pp. 680-688; 8 plates.
255. 1914—Grasshopper Control in the Southern Division of Kansas (with P. W. Claassen). Jour. Ec. Ent., vol. VII, No. 1, pp. 73-83; 5 plates.
256. 1915—Report of Official Entomologist. Trans. St. Hort. Soc. of Kan., vol. XXXIII, pp. 37-40.
257. 1915—Some Economic Results of the Year. Jour. Ec. Ent., vol. VIII, No. 2.
258. 1916—By-products of the Orchard. Country Gentleman, vol. LXXXI.
259. 1916—Report of the State Entomologist. Rep. Kan. St. Ent. Com. for 1915-1916, pp. 11-15.
260. 1917—Practical Insecticides and Proper Application. Trans. Kan. St. Hort. Soc., vol. XXXIV, pp. 182-192.
261. 1917—Spring Cankerworm: An Orchard and City Problem. Trans. Kan. St. Hort. Soc., vol. XXXIV, pp. 209-212.
262. 1918—Municipal Control of Spring Cankerworm. Jour. Ec. Ent., vol. XI, No. 2, pp. 164-166.
263. 1918—The Wood Lot. Bien. Rep. Kan. St. Hort. Soc., vol. XXXV, pp. 144-150.

264. 1918—Report of the State Entomologist. Rep. Kan. Ent. Com. for 1917-1918, pp. 12-19.
265. 1918—Report of Entomologist for 1918. Bien. Rep. Kan. St. Hort. Soc., vol. XXXV, pp. 171-173.
266. 1920—Insect Life in Relation to Wheat. Rep. Kan. St. Bd. Ag., vol. XXXIX, No. 155, pp. 249-271.
267. 1921—Coöperation: Nurseryman and Entomologist. American Nurseryman, vol. XXXV, No. 5, pp. 106-107.
268. 1922—Measures of Prevention, I. Bien. Rep. Kan. St. Hort. Soc., vol. XXXVI, pp. 178-182.
269. 1922—Measures of Prevention, II. Bien. Rep. Kan. St. Hort. Soc., vol. XXXVI, pp. 184-194.
270. 1922—The Entomologist and Florist: Their Common Problems. The American Nurseryman, vol. XXXV, No. 5, pp. 106-107

KENNEDY, C. H.

271. 1917—Dragon Flies of Kansas. Bul. of the Dept. of Ent., University of Kansas, No. 11, pp. 127-160; 7 plates

LAWSON, P. B.

272. 1917—The Coccidæ of Kansas. Bul. of the Dept. of Ent., University of Kansas, No. 11, pp. 161-279; 103 figures.
273. 1920—The Cicadellidæ of Kansas. Science Bulletin, vol. XII, No. 1, pp. 1-306; 17 plates.
274. 1920—The Cicadidæ of Kansas. Science Bulletin, vol. XII, No. 2, pp. 306-376; 10 plates.
275. 1922—List of the Cicadellidæ of Kansas (Homoptera). Trans. Kan. Acad. Sci., vol. XXX, pp. 331-336
276. 1922—List of the Grasses of Douglas County. Trans. Kan. Acad. Sci., vol. XXX, pp. 336-339.
277. 1922—The Genus *Acinopterus* (Cicadellidæ). Science Bulletin, vol. XIV (this number).
278. 1922—The Membracidæ of Kansas. Science Bulletin, vol. XIV (this number)

WELLHOUSE, WALTER H.

279. 1915—Results of Experiments on the Use of Cyanide of Potassium as an Insecticide. Jour. Ec. Ent., vol. IX, No. 1, pp. 169-170.
280. 1916—Formulas for Destroying Injurious Insects and Plant Diseases. University of Kansas Circular, No. 4
281. 1917—The Cankerworm: An Orchard and Shade-tree Pest. Bul. Dept. of Ent., University of Kansas, No. 11, pp. 283-315; 3 plates.

WILEY, GRACE OLIVE.

282. 1922—Life History Notes on Two Species of Saldidæ. Science Bulletin, vol. XIV (this number).
283. 1922—Biological Notes on *Curicta* (Nepidæ). Science Bulletin, vol. XIV (this number).

YOUNG, B. P.

284. 1918—Ecological Notes on the Spring Cankerworm (*Paleacrita vernata*). Can. Ent., vol. L, No. 8, pp. 267-277; figures, 2.

THE KANSAS UNIVERSITY SCIENCE BULLETIN

VOL. XIV, No. 3—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 3.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

TABLE OF CONTENTS.

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 3.

The Membracidæ of Kansas.

By P. B. LAWSON,
Professor of Entomology, University of Kansas.

INTRODUCTION.

THE writer has been interested in recent years in a systematic study of the Homoptera of Kansas. He has previously published papers on the Coccidæ, Cicadellidæ and Cicadidæ of the state, listing over 300 species of the members of these families known to occur within the borders of Kansas.

The membracids of the state have been previously studied by Miss Hazel Branch, who in 1914 published a paper in the KANSAS UNIVERSITY SCIENCE BULLETIN, volume 8, on the biology of the Membracidæ of Kansas. In that paper she listed nineteen species from the state. Since that time quite a little collecting has been done, until to-day, including some species taken around Kansas City, Mo., which species are therefore sure to occur in eastern Kansas also, there are records of the occurrence of at least fifty-five species of tree hoppers in our fauna. Further collecting will of course reveal a goodly number of additional species, but the writer has thought it advisable to bring our data up to date at this time.

The writer is greatly indebted to Dr. W. D. Funkhouser, of the University of Kentucky, who has made many determinations for him and been very generous in giving helpful suggestions and encouragement during the course of this study. Moreover, his paper on the biology of the Membracidæ of the Cayuga Lake Basin has been very freely drawn upon, especially in the use of the technical descriptions.

Through the kindness of Professors Geo. A. Dean and Roger Smith, the records of the Kansas State Agricultural College are included in this paper, most of the records from Riley county and several others being from that collection.

DISTRIBUTION.

The Membracidæ, though primarily a tropical and subtropical family, are nevertheless found widely scattered and are well represented in temperate regions. Authorities are agreed that they are best represented in the fauna of Central and South America, but it seems certain that when the fauna of Africa and Southern Asia have been as carefully studied that these regions will also be found to be very rich in these insects.

Dr. W. D. Funkhouser gives the following distribution of the family according to geographical life zones:

Palearctic region:

(Europe, the temperate parts of Asia, and the north of Africa; Iceland and the islands of the Atlantic; limited by the Himalayas.)

Very poorly represented. Only two or three genera on the entire continent of Europe, but two species in Great Britain, two species in Russia, and none reported from Iceland. A few in northern Africa, chiefly forms that have migrated from the south.

Ethiopian region:

(Africa and its islands, except the northern parts; Arabia.)

Rich in genera and species. Little work has been done on these forms of the family, but there is evidence of an abundant membracid fauna.

Oriental region:

(India and the East Indies.)

Extremely rich both in number of forms represented and in number of individuals. The center of distribution for the subfamily Centrotinæ.

Australian region:

(Australia, New Zealand and neighboring islands.)

Well represented by rather distinct forms. The region has been fairly well worked and has yielded a large number of species.

Nearctic region:

(America north of Mexico; Greenland).

Forty or fifty genera, gradually becoming less abundant northward. A few species common in Canada as far north as Perry Sound. None reported from Greenland.

Neotropical region:

(Mexico, West Indies, Central and South America.)

The most important of all the regions for the Membracidæ. Central America and the northern part of South America have yielded as many species as all the rest of the world together.

Altogether over 300 genera have been erected, which contain something like 1,500 species. Many of these genera are found in

more than one of the above regions, but the number of such species is seemingly rather limited. Thus the American genera *Ceresa* and *Stictocephala,* while well represented in both the Nearctic and Neotropical regions, scarcely have a single species that occurs in both regions. On the other hand, it is well known that some forms, such as *Micrutalis calva* (Say), are found in both the United States and the West Indies.

In North America the members of this family are best represented in Mexico. As we advance northward they become fewer and fewer till comparatively few species are found in Canada, where they reach their northern limit. Van Duzee lists 41 genera in his catalogue of the Hemiptera of North America north of Mexico. It is perhaps safe to say that the number of genera for this region does not exceed fifty. The number of species is listed at 185, which compares very favorably with the 25 cercopids and the 74 cicadas, but falls far short of the 357 fulgorids and the 698 cicadellids which occur in the same territory. Thus it is seen that in the United States this family stands midway in membership among the five families of the Homoptera-Auchenorhynchi.

So far the membracid fauna of Kansas is known to be represented by 20 genera. Further collecting will doubtless reveal the presence of several other genera, and of course the number of species will also be increased, for, after all, there has been rather little attention paid to this family in the work of past collectors in this state. This is shown by the fact that only about 50 out of the 105 counties of the state have as yet furnished us with specimens. However, these counties are so well distributed as to give us a very fair idea of the membracid fauna of the entire state.

The genera *Telamona* and *Cyrtolobus* show the most species in the state, each having some ten or eleven species. These genera are, however, not the ones that are most commonly seen, for both *Stictocephala* and *Ceresa* are far more abundant as to individuals, *Ceresa bubalus* (Fabr.) being by far the commonest species in the state. Close to the two latter genera comes *Micrutalis,* the species *calva* having been taken in about fifteen counties. *Campylenchia latipes* is also very common throughout the alfalfa fields of the state. *Vanduzea triguttata* (Burm.) occurs in enormous numbers when taken, as does *Entylia concisa* (Walk.), but hitherto these species have not been taken in many places within our borders.

EXPLANATION OF PLATE I.

1. Pronotum and head of *Ceresa bubalus*. *sp*, suprahumerals; *m*, metopidium; *ha*, humeral angles.

2. Cephalic aspect of head of *Ceresa bubalus*. *es*, epicranial suture; *o*, ocellus; *v*, vertex; *e*, compound eye; *g*, gena; *lo*, lora; *cl*, clypeus; *l*, labrum; *ep*, epipharynx; *la*, labium.

3. Caudal aspect of head of *Ceresa bubalus*. *oc*, occiput; *of*, occipital foramen; *pg*, postgena; *e*, compound eye; *la*, labium.

4. Lateral aspect of head of *Ceresa bubalus* *oc*, occiput; *v*, vertex; *e*, compound eye; *g*, gena; *cl*, clypeus; *pg*, postgena; *l*, labrum; *ep*, epipharynx; *mx*, maxillary stylets; *md*, mandibular stylets; *la*, labium.

5. Pronotum of *Ceresa bubalus*. *sp*, suprahumerals; *ha*, humeral angles; *m*, metopidium; *dc*, dorsal carina; *pp*, posterior process.

6. Metathoracic leg of *Ceresa bubalus*. *c*, coxa; *tr*, trochanter; *f*, femur; *t*, tibia; *ta*, tarsus.

7. Prothoracic leg of *Ceresa bubalus*.

8. Prothoracic leg of *Campylenchia latipes*.

9. Tegmen of *Ceresa bubalus*.

10. Hind wing of *Ceresa bubalus*.

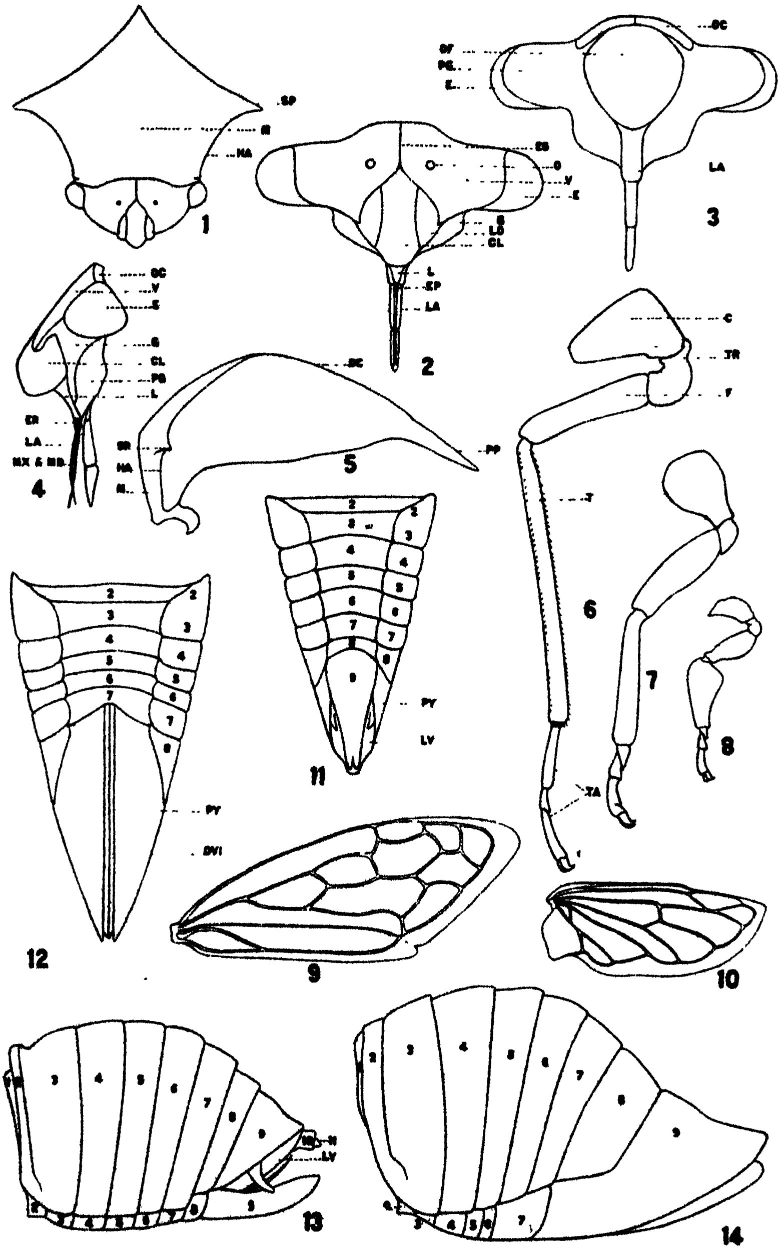
11. Ventral aspect of abdomen of male *Ceresa bubalus*. *2-9*, sternites; *2-8*, pleurites; *py*, pygofer or ninth tergite; *lv*, lateral valve.

12. Ventral aspect of abdomen of female *Ceresa bubalus*. *2-7*, sternites; *2-8*, pleurites; *py*, pygofer or ninth tergite; *ovi*, ovipositor.

13. Lateral aspect of abdomen of male *Ceresa bubalus*. *1-11*, tergites; *2-9*, sternites; *lv*, lateral valve.

14. Lateral aspect of abdomen of female *Ceresa bubalus*. *1-9*, tergites; *2-7*, sternites.

PLATE I.



STRUCTURAL CHARACTERISTICS.

The outstanding characteristic of the membracids is their remarkably developed pronotum. This sclerite is usually enlarged so as to cover most of the thorax and much of the abdomen, and while in our species it is often extended into rather regularly formed processes, yet in many tropical species these processes assume the most irregular and grotesque shapes. In the subfamily Centrotinæ, however, the pronotum is not thus enlarged, but is so small that the greater part of the scutellum is left exposed.

As in all insects, the body is divided into three regions. The head is quite characteristically homopterous, fitting against the coxæ of the prothoracic legs, between which lies the beak. At its lateral extremities are the well-developed *compound eyes,* while the *simple eyes* or *ocelli* are found on the *vertex,* the paired sclerite forming the greater part of the cephalic aspect of the head. The ocelli are always paired and in a line with each other and the compound eyes, though their distance from each other and from the compound eyes varies.

The setaceous *antennæ* are found under the margin of the vertex on either side of the *clypeus.* The first three segments are large, but the rest of the organ is composed of a large number of small segments which decrease in size toward the apex.

The vertex is a paired sclerite lying on either side of the base of the Y-shaped *epicranial suture.* The presence of this suture would indicate a more primitive position for this family than for the Cicadellidæ, where no signs of it are present.

Between the arms of the epicranial suture and forming the apex of the head is the clypeus. This sclerite is often characteristic in the length of its apex and in its relation to the lateral margins of the vertex. At its apex it is turned backward, forming a rounded lobe, caudad of which are the *genæ.* The latter sclerites are seen to form the lateral portions of the head, extending between the eyes and the clypeus, and bearing the antennæ. The *postgenæ* occupy most of the caudal aspect of the head, forming, with the dorsal occipital sclerites or *occiput,* most of the boundary of the *occipital* foramen. The *loræ* are found on either side of the clypeus and labrum as two more or less distinct sclerites with rounded lateral margins.

The *beak* or *labium* consists of three segments, as in other Homoptera, and contains in a groove the *mandibular* and *maxillary*

stylets. The *labrum* is large and caudad of the clypeus, bearing the more or less membranous *epipharynx* at its tip. All the mouth parts are typical of the ordinary sucking phytophagous insect.

The thorax, as in all insects, consists of three segments. For our purposes only a brief discussion of the dorsal sclerite of the prothorax will be necessary. This sclerite, the *pronotum*, as already mentioned, is the chief characteristic of the family. It is one of the finest examples of the biological phenomenon of orthogenesis that is to be found. In our North American membracids it is comparatively simple as compared with its appearance in many Neotropical genera, such as *Sphongophorus* and *Cyphonia*. But even in our fauna it assumes such diverse forms as to give us the best generic, and often also specific characters for the classification of the members of this family. The following parts have been named and are used in the descriptions which follow:

1. *Metopidium*. The cephalic area of the pronotum, extending from the base of the head to the front of the dorsum.
2. *Humeral angles*. The angles of the pronotum just above the bases of the wings.
3. *Suprahumerals*. The lateral projections above the humeral angles.
4. *Dorsal carina*. The ridge usually extending the length of the pronotum.
5. *Posterior process*. The caudally directed portion of the pronotum.

The three segments of the thorax each bear a pair of legs, which are composed of the usual segments, the *tarsi* being three-segmented. The *coxæ* are usually stout, the *trochanters* rather small and bent, the *femora* large and stout, and the *tibiæ* usually long, slender and hairy. In the subfamily Membracinæ and in some Centrotinæ, the tibiæ are wide and flat or foliaceous, especially so in the prothoracic and mesothoracic legs.

The last two thoracic segments each bear a pair of wings, which are of value in systematic work, not only in their venation, but also in their relation to the pronotum.

The abdomen consists of eleven segments, the last two forming the anal tube. Most of these segments show a distinct tergite, pleurites and sternite. Of these sclerites the tergite is by far the largest, forming both the dorsal and lateral portions of the segment; and in the case of the female ninth segment, nearly inclosing the segment, coming clear down to the sides of the ovipositor, in

this sex there showing externally but six sternites, those of the second to seventh segments, inclusive. In the male the ninth tergite is not as large, for in this sex the sternites of segments two to nine, inclusive, all show clearly. This tergite bears, however, on either side, a pair of broad lobes or plates which Funkhouser calls the lateral valves. These, he thinks, may be the pleura of the ninth segment and of use in copulation. They may project caudad or turn mesad—a character of generic value. They frequently bear variously shaped processes or teeth, which, as far as the writer has observed, are constant in form and position for the various species, and are therefore good specific characters.

The sternite of the seventh segment of the female differs in different species, and is therefore of systematic value, as is also the ninth sternite or sternal plate of the male. The latter is constant in shape and extent of apical splitting within the species, and this makes it of value as a taxonomic character.

THE MALE GENITALIA.

As in the Cicadellidæ, the abdomen of the male ends in what Sharp calls the "terminal chamber" in the case of the Pentatomidæ. This chamber is bounded above by the anal tube and ninth tergite, laterally by the lateral valves, and ventrally by the ninth sternum. Within this chamber are found the genital organs of the male, their position and structure being exactly homologous with the male genitalia of the leaf hoppers.

The *styles* or *claspers* are always paired, both members of the pair being alike, and fastened to the sternal plate by apparently passing, near their middle, through the membrane forming the dorsal surface of the plate. The cephalic portion of the clasper projects into the abdominal cavity, frequently reaching the sixth segment, though usually extending only as far as the eighth or ninth. It does not seem to vary much in the different species. The apical portion, however, is characteristic in its shape and apical structure, sometimes being nearly straight, at other times more or less strongly curved, and ending either in a plain acute point or in variously shaped and toothed extremities. So far the writer has found no two species in which the styles are alike in both size and structure.

Canon Fowler, in the "Biologia Centrali-Americana," states that in the genus *Ceresa* the styles are long and pointed, while in the genus *Stictocephala* they are short and obtuse at the apex. This is undoubtedly frequently true, but the writer has found that it does

not always hold in the members of these genera as the latter are now constituted. Thus, while in *Stictocephala festina* the above-mentioned condition holds good, it is not true of *S. lutea,* for the latter possesses styles just as long and pointed as in several members of *Ceresa,* notably *C. bubalus.*

As in the Cicadellidæ, the styles are united by a small sclerite, which varies in shape in the various genera and species, but is always of the same shape within the species. This sclerite the writer has called the "*style-œdagus connective,*" or more simply, the "*connective.*" The former name shows its usual function in the leaf hoppers, for usually it unites not only the two styles, but at its distal end is united to the base of the œdagus. This condition prevails in all the tree hoppers thus far examined. Its relation to the styles, however, is apparently different in the two families, for in the leaf hoppers each style sends out a distinct chitinous process to which it is fastened, while in the tree hoppers this chitinous process is not usually present, but rather each style, at the point of attachment to the connective, gives off a dorsal membranous fold which unites with the connective, the two folds appearing heart-shaped basally when viewed from above.

In all the species so far examined the connective appears as a rather thin, usually flat sclerite, frequently showing a distinct tendency to fold longitudinally along a median keel, thus drawing the two styles closer together. It is usually quite small, but in some forms, notably *Ceresa borealis,* it is well developed.

The writer has not tried to determine the morphological status of the connective. Kornhauser calls it the ninth sternite. Funkhouser does not mention it, but feels that the last sternal plate or the valves are the ninth sternite. That it is a sternite cannot be doubted, and the writer hopes to discuss its exact position in a later paper on the genitalia of the Homoptera-Auchenorhynchi.

The *œdagus,* or *penis sheath,* seen laterally, is usually a V-shaped organ, the mouth of the V looking caudad or dorsad. The anterior or dorsal arm extends up to the base of the anal tube, the latter always being fastened to it, usually at a slight excision near its apex. As far as our present studies go, the shape of this arm seems to vary more or less even within the species, sometimes being rather narrow and straight, then changing till it is frequently quite broad and variously bent. The lower or posterior arm is the penis sheath proper. The penis enters it just above the usual basal angle by which the œdagus is united to the connective. This basal angle may

often be prolonged into a distinct cephalic process. This ventral arm varies greatly in different genera and species, but, as far as our observations go, is always constant in shape within the species. It usually extends more or less dorso-caudad, though sometimes its apex is bent distinctly dorsad and may even extend dorso-cephalad. The course of the penis through this arm is usually easy to trace in caustic potash specimens.

In the genera *Ceresa* and *Stictocephala* the functional orifice is usually along the ventral side of this arm and at quite a distance from the apex. This opening in these genera is usually quite long and is guarded by a distinct membranous external sheath. In *S. festina,* however, the penis opens apically, while in *Campylenchia, Telamona* and others it opens at or near the apex. In every case, however, the opening seems to be guarded by the external membrane and is constant in position within the species. The shape of the apex also is constant for the species; in fact, the whole organ seems to afford an excellent specific character for use in systematic work. Canon Fowler's characterization of the œdagus of *Stictocephala* does not hold good for all the species of the genus.

The cephalic portion of the styles and the dorsal arm of the œdagus are practically internal parts. It seems as though these parts have distinct layers added to them at various intervals, thus adding to the length of the former and to the width of the latter This may account for the variable condition seen in these organs, even within the species. The terminal portions, however, seem to be constant.

The *sternal plate,* both as to shape and the extent of its division into two parts, is an excellent and readily available character for taxonomic work. It may be the ninth sternite, but the question as to its possible homology with abdominal appendages at once arises. At any rate, it seems to be exactly homologous with the *plates* of the Cicadellidæ.

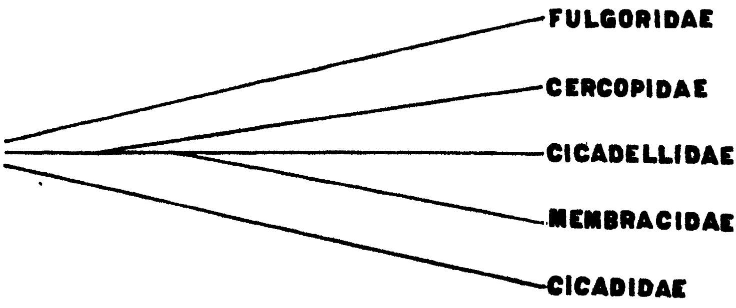
Further work with these genital organs will undoubtedly lead to their greater use in systematic work. The writer has found that specimens identified as identical can frequently be separated and properly classified by a study of these organs. It is to be hoped that the various genera will be studied from this standpoint in the days to come. If they are the writer feels that several generic changes will be made. Thus it would seem that the genus *Stictocephala* should be divided, for the genitalia of *S. festina* and *S. lutea* cannot possibly belong to members of the same genus. On the other hand,

the genitalia of the genera *Telamona* and *Telonaca* are so near alike that it seems certain that the latter should never have been separated from the former.

PHYLOGENY OF THE FAMILY.

The membracids belong to that group of the Homoptera known as the Auchenorhynchi, which differs from the rest of the members of the order, the Sternorhynchi, in that in the latter the mouth parts seemingly arise from between the prothoracic legs, instead of from the head, as in the former.

In this group are five families, arising from three different stems, of which it seems clear that the Cicadidæ arise from the lowest stem and the Fulgoridæ from the highest. In between these two families are the closely related membracids, cicadellids and cercopids. As pointed out in his paper on the Cicadellidæ of Kansas, the writer accepts the conclusions of Funkhouser and others in making the membracids the lowest of these three families and the cercopids the highest. This relationship would therefore be expressed as follows:



In the above figure it will be noticed that the Cercopidæ are represented as branching off earlier from the median stem than the other two families. This seems evident when their life history is considered, for they have been isolated long enough to enable them to perfect a method of protection against parasitism. Certainly the development of the production of the spittle mass which incloses the nymph could not have occurred quickly, but must have taken a relatively long period of time to attain its present perfection.

LIFE HISTORY.

Most of the members of this family occur on small trees or shrubs, particularly those growing near the edges of woods or out in the open. In the main they seem to avoid the shade and prefer those

situations where they receive the most sunshine. Most of our species occur on trees, but there are several that are found on shrubs, and some occur on weeds, grasses and clovers.

The majority of our species of tree hoppers are found to overwinter in the egg stage. This stage, therefore, occupies by far the longest period in the life history of the insect. The eggs are deposited for the most part in the twigs. Here they may be placed in simple incisions in a row, or the well-known method of oviposition of *Ceresa bubalus* may be used where two curved incisions, facing each other, are made. Some species also oviposit in the buds, while our common *Entylia concisa* lays its eggs in the veins of the leaf of *Ambrosia trifida.* Funkhouser gives the axils of the leaves as the place where *Telamona ampelopsidis* oviposits, while *Thelia bimaculata* lays most of its eggs in the roots or on the stem below the surface of the soil.

While most of our treehoppers hibernate in the egg stage, Funkhouser states that *Entylia bactriana* and *Publilia concava* overwinter as adults. The writer has taken *Entylia concisa* late in the fall in the rubbish and grass around its host plant. In fact, on September 8 he has found the eggs of this species just hatching, while on September 11 he has taken all the nymphal instars and newly matured adults on a single leaf.

The number of generations in a season is usually one, by far the larger number of our species having a single annual brood. Some species, however, have two broods and some probably three, while *Vanduzea arquata* is said by Funkhouser to have as many as four generations. The same is seemingly true of our *Vanduzea triguttata.*

The usual life history of a tree hopper has been summarized by Doctor Funkhouser as follows:

Eggs: Laid in fall, hatch in early spring.

Nymphs: Emerge about the middle of May and require about six weeks to reach maturity.

Adults: Are common about July 1 and persist throughout summer and fall.

Mating: Takes place the first week after emergence.

Oviposition: Occurs within a week after mating.

Broods: Usually one but sometimes more, dependent on weather conditions.

For a single individual the life cycle would be somewhat as follows:

Egg stage: From September to middle of May		8½ months
First instar	1 week	
Second instar	1 week	
Third instar	1 week	
Fourth instar	1 week	
Fifth instar	2 weeks	
Nymph:		
Total, from middle of May to July		1½ months
Adult: From July to October (inclusive)		4 months
Entire life		14 months

The above dates of course apply to New York and would differ somewhat from what occurs in Kansas.

One of the easiest ways to find certain species of tree hoppers is to notice the more readily seen ants which attend so many of our common forms. In this way *Vanduzea triguttata* and *Entylia concisa* are very easily located. It is well known that the ants obtain honey dew from these insects, although there are many species of tree hoppers which do not seem to furnish this substance in sufficient quantity to attract the attention of these visitors.

It is well known that these insects are frequently parasitized. Hymenopterous parasites of the family Dryinidae have been known to occur in several genera of tree hoppers. Doctor Kornhauser worked out in great detail the life history of such a parasite, *Aphelopus theliæ*, which parasitizes *Thelia bimaculata*. In addition, tree hoppers are often the prey of predaceous insects and spiders. Of such predaceous enemies there are a number of kinds, but it is quite doubtful if these enemies are a very vital factor in the natural control of the members of this family.

ECONOMIC IMPORTANCE.

The chief damage done by tree hoppers is by their oviposition. The records of injury to young orchards, especially to apple, are many. The type of oviposition that may really be serious is that represented by the egg punctures of *Ceresa bubalus*, and this species is seemingly the most often accused of all the species concerned. The writer has seen young orchards in which the outer twigs were all roughened up by the oviposition scars, and such cases are numerous in the literature. The exact damage done, however, is problematical, many inclining to the opinion that as a rule the damage done is not serious. Others hold that in after years such scars will weaken the branches, causing them to be more easily broken off by the wind, and also furnishing good points of attack for borers. The

wounds made also doubtless furnish good points of entrance for certain fungous diseases.

Cases are on record also where the buds of certain trees were seriously injured by the deposition of eggs within them. Damage from such oviposition always results when eggs are deposited deeply in small buds. In this respect the species concerned most frequently are *Ceresa taurina, Stictocephala inermis* and *Enchenopa binotata*. The species most injurious to stems belong to the genera *Ceresa* and *Stictocephala*.

Inasmuch as the nymphs of the most injurious species prefer to feed on the more succulent weeds and grasses in the orchard, the clean culture of badly infested orchards and the getting rid of near-by weed patches in the early summer, will usually be all the control measures necessary. Frequently in case of very severe infestations the careful pruning of the worst-infested twigs after egg deposition is a desirable practice.

LIST OF THE SPECIES.

Microcentrus caryæ (Fitch).
Campylenchia latipes (Say).
Enchenopa binotata (Say).
Ceresa diceros (Say).
Ceresa albescens Van D.
Ceresa bubalus (Fabr.)
Ceresa taurina Fitch.
Ceresa palmeri Van D.
Ceresa borealis Fairm.
Ceresa brevicornis Fitch.
Stictocephala inermis (Fabr.)
Stictocephala festina (Say).
Stictocephala lutea (Walk.).
Acutalis tartarea (Say).
Micrutalis calva (Say).
Carynota mera (Say).
Thelia bimaculata (Fabr.).
Thelia uhleri Stal.
Glossonotus acuminatus (Fabr.)
Heliria cristata (Fairm.).
Heliria scalaris (Fairm.).
Telamona pyramidata (Uhl.).
Telamona viridia Ball.
Telamona obsoleta Ball.
Telamona decorata Ball.
Telamona querci Fitch.
Telamona ampelopsidis (Harr.).
Telamona tristis Fitch.
Telamona unicolor Fitch.
Telamona extrema Ball.
Telamona collina (Walk.).
Telamonanthe rileyi (Godg.).
Telamonanthe modesta (Godg.).
Archasia galeata (Fabr.).
Archasia belfragei Stal.
Smilia camelus (Fabr.).
Cyrtolobus celsus Van D.
Cyrtolobus fuliginosus (Emns.).
Cyrtolobus arcuatus (Emns.).
Cyrtolobus fenestratus (Fitch).
Cyrtolobus tuberosus (Fairm.).
Cyrtolobus vau (Say).
Cyrtolobus griseus Van D.
Cyrtolobus cinereus (Emns.).
Cyrtolobus querci (Fitch).
Cyrtolobus muticus (Fabr.).
Ophiderma salamandra Fairm.
Ophiderma flaviguttula Godg.
Ophiderma flava Godg.
Vanduzea triguttata (Burm.).
Entylia concisa Walk.
Publilia concava (Say).
Publilia modesta Uhl.
Publilia reticulata Uhl.

SYSTEMATIC TREATMENT OF KANSAS SPECIES.

The three subfamilies represented in Kansas may be separated by the following key:

KEY TO SUBFAMILIES.

A. Scutellum distinct, not concealed by the pronotum. Centrotinæ.
AA. Scutellum wanting or concealed by the pronotum.
B. Tibiæ, especially anterior ones, foliaceous. Membracinæ.
BB. Tibiæ not foliaceous. Smiliinæ.

SUBFAMILY CENTROTINÆ (Spinola).

This subfamily, represented in the United States by about half a dozen genera and a few more species, is readily separated from the other subfamilies by the presence of a usually visible scutellum. The genus *Microcentrus* occurs in Kansas.

GENUS MICROCENTRUS (Stal).

The members of this genus that occur in the United States have a pronotum that leaves a large part of the scutellum well exposed and ends in a slender terminal process which extends beyond the divided apex of the scutellum.

Both members of this genus known to occur in the United States have been taken in Kansas. They may be separated by the following key:

KEY TO SPECIES.

A. Prothorax bearing a pair of laterally flattened horns. *perdita*.
AA. Prothorax without laterally flattened horns. *caryæ*.

Microcentrus caryæ (Fitch).

Uroxiphus caryæ Fitch, Homop. N. Y. St. Cab., p. 52, 1851.
Centrotus caryæ Walker, List Homop., IV, p. 1147, 1851.
Microcentrus caryæ Stal, Of. Vet. Akad. Forh., XVI, p. 295, 1869
Phaulocentrus caryæ Fowler, Biol. Centr. Am., Homop., II, p. 159, 1896

Funkhouser gives the following technical description:

Gray-brown mottled with black; entire body broad and flat; pronotum roundly swollen above line of abdomen and wings; wings broadly tectiform.

Head perpendicular, twice as broad as long, roughly sculptured, closely punctate, densely pubescent, deep brown at base; eyes prominent, extending beyond lateral margins of pronotum, dark brown margined with lighter; ocelli small, pearly, farther from the eyes than from each other, with deep depression between them; clypeus prominent, broad, lighter in color than vertex above, extending far below lateral margin of head.

Prothorax subspherical, with high median carina, coarsely punctate, pubescent; light brown marked with black on median ridge and above head; posterior margin truncate except for narrow process, which projects to angles of

tegmina and short sharp tooth on each latero-posterior angle. Scutellum broadly exposed, wide at base, truncate at tip, which does not reach apex of posterior process.

Tegmina translucent, pubescent, inner margins straight and meeting at median dorsal line; veins prominent and nodulate; apices of tegmina extending beyond tip of abdomen. Legs and undersurface of body light brown mottled with white. Undersurface of abdomen often tomentose.

Length, 9-10 mm.; with, 3 mm.

Distribution. Van Duzee records this species from Ontario, New York, New Jersey, Pennsylvania, North Carolina and Ohio. In the Crevecoeur collection is a specimen taken in Pottawatomie county, Kansas, thus establishing its occurrence in the state.

Hosts. As indicated by the specific name, this species occurs on hickory. Funkhouser reports it on oak also. Matausch gives swamp oak and walnut, and Goding mentions the latter.

Microcentrus perdita (Amyot & Serville).

Ledra perdita Amyot & Serville, Hemip., p. 577, pl. 11, fig. 5, 1843.
Centruchus liebecki Goding, Ill. St. Lab. Nat. Hist., iii, p. 471, 1894.
Microcentrus perdita Baker, Can. Ent., xxix, p. 38, 1897.
Centruchoides perdita Van Duzee, Bul. Buf. Soc. Nat. Sci., ix, p. 117, 1908.

Goding describes this species as follows:

Yellow-ferruginous, silky white between lateral horns; behind horns a spot on costal margin, near base of tegmina. Head black, broad, eyes very prominent; base convex, griseous, lower part of face strongly declivous; four roughened carinæ pass along face from base downward, the ocelli being in the two internal ones, the outer ones being contiguous to the eyes; part of face below eyes triangular, apex yellow. Ocelli equidistant from each other and the eyes. Prothorax convex, lateral angles slightly produced, a prominent median carina extending from base to apex nearly black. Above the lateral angles, on each side, is a long horn or protuberance, flattened laterally, slightly curving upward, outward and forward, the apex truncated; width of base and apex equal. Apex of scutellum bidentate, the teeth ivory-white; posterior margin of prothorax with a very slender tooth or style, extending backward on each side of posterior process of prothorax, a little distant from it. The entire surface of the prothorax densely and regularly punctured. Apex of tegmina far surpassing tip of abdomen; a black spot on the internal margin a short distance from the apex; another black spot on the costa, about one-third the distance from the base. Tarsi black; legs mottled with ferruginous and grayish-yellow; tibiæ triquetrous. Tegmina lightly ferruginous and opaque.

Length to apex of tegmina, 8.5 mm.; width at lateral angles, 3.2 mm.

Distribution. Reported from Massachusetts, New Jersey, Pennsylvania, Florida, Colorado and New Mexico. Specimens have also been taken in Riley county, Kansas.

Hosts. Van Duzee reports this species from scrub oak.

SUBFAMILY MEMBRACINÆ (Stal).

The members of this subfamily differ from all other membracids of our fauna by having the prothoracic and mesothoracic tibiæ foliaceous. As in the following subfamily, the pronotum conceals the scutellum.

Two genera occur in Kansas which may be separated by the following key:

KEY TO GENERA.

A. Lateral ridges of anterior horn nearer dorsal carina; ventral carina of horn not distinctly foliaceous. *Campylenchia.*

AA. Lateral ridges of anterior horn midway between dorsal and ventral carinæ; latter distinctly foliaceous *Enchenopa*

GENUS CAMPYLENCHIA (Stal).

This genus, the chief characteristics of which appear in the above key, is represented by a single though widely spread species in the United States.

Campylenchia latipes (Say).

(Pl. VI, figs. 9, 10.)

Membracis latipes Say, Long's 2nd Exped., ii, p. 302, 1824, Compl. Writ., i, p. 202.
Enchophyllum latipes Fitch, Homop. N. Y. St. Cab., p. 47, 1851.
Enchenopa latipes Walker, List Homop., ii, p. 482, 1851.
Enchenopa antonina Walker, List Homop., ii, p. 488, 1851.
Enchenopa venosa Walker, List Homop., ii, p. 488, 1851.
Enchenopa frigida Walker, List Homop., ii, p. 490, 1851.
Enchenopa bimacula Walker, List Homop., ii, p. 491, 1851.
Campylenchia curvata Stal, Hemip. Fabr., ii, p. 43, 1869.
Enchenopa curvata Uhler, Bul. U. S. Geol. Geog. Surv., i, p. 343, 1876, iii, p. 457, 1877.
Aconophora curvata Butler, Cist. Ent., ii, p. 349, 1877.
Echenopa rectidorsum Buckton, Monog. Membr., p. 49, 1903.
Campylenchia latipes Van Duzee, Can. Ent., xliv, p. 326, 1912.

Funkhouser gives the following technical description:

Uniform cinnamon brown, densely punctate, sparingly pubescent; single porrect pronotal horn projecting forward over head; head and first two pairs of legs broadly foliaceous, hind legs spined; tegmina opaque, punctate at basal and costal margins.

Head quadrate, somewhat declined, shining brown somewhat mottled with darker, lightly punctate, densely pubescent; eyes prominent; ocelli small, pearly, equidistant from each other and from the eyes and situated on a line passing through centers of eyes; clypeus very broad, shining, scarcely punctate, broadly truncate at apex, tip strongly pubescent.

Prothorax produced anteriorly into a long, flattened horn, ridged in center and foliaceous above and below, varying greatly in length and degree of curve; posterior process strong, tectiform, reaching internal angles of tegmina; median dorsal carina strong and percurrent; entire pronotum concolorous, lightly punctate, sparingly pubescent with golden hairs; median lateral ridge reaching lateral margin.

Tegmina yellow-opaque; basal and costal areas punctate and pubescent;

veins distinct, broad, and slightly pubescent; five apical and two discoidal cells; hind wings iridescent. Two anterior pairs of legs broadly spatulate and lightly pubescent at margins; posterior tibiæ armed with black-tipped spines; tarsi much produced and lighter in color. Undersurface of body chocolate brown.

Length: from head to apices of elytra, 5 mm.; from tip of promotal horn to apices of elytra, 8 mm. Width between humeral angles, 2 mm.

Internal male genitalia. Styles with long flattened anterior process, widest apically, with a distinct prominence at attachment to connective, caudad of which they are peculiarly wrinkled and show a small but distinct mesal lobe, then widest just caudad of wrinkled portion, after which they curve laterad, ending in a doubly pointed apex, of which the terminal tooth is larger and more slender than the anterior one, the apical third of the styles bearing a few short hairs; connective short and wide, basal half with a heavily chitinized and flattened V-shaped portion; œdagus, viewed laterally, stout and broadly V-shaped, widest at the distinctly notched base, the upper basal process also slightly notched, narrowest at the bend and then widening till near the apex, the caudo-dorsal portion of which is only slightly chitinized, the functional orifice being at about the middle of this slightly chitinized area, the upper portion of the apex bearing a few distinct file-like teeth.

Distribution. Van Duzee gives the following distribution for this species: Ontario, Maine, Vermont, New York, New Jersey, Pennsylvania, North Carolina, Illinois, Iowa, Kansas, Missouri, Colorado, Wyoming, Montana, Texas, New Mexico, Arizona, and California. Osborn reports it from Florida. It is thus seen to extend throughout the United States.

In Kansas specimens have been taken in the following counties: Douglas, Ottawa, Pratt, Hodgeman, Clark, Pottawatomie, Labette, Bourbon, Wabaunsee, Russell, Riley, Ellis, Ellsworth and Wyandotte.

Hosts. Funkhouser gives the following hosts for this species: Aster, daisy, joe-pye weed, alfalfa, prickly lettuce, wild carrot. Miss Branch mentions golden rod and sensitive rose. Gillette and Baker report it from *Glycyrrhiza lepidota, Psoralea tenuiflora* and *Apocynum androsacmifolium.* The writer has found it very abundantly on alfalfa.

GENUS ENCHENOPA Amyot & Serville.

But two members of this genus are known to occur in the United States. The widely distributed *E. binotata* occurs in Kansas.

Enchenopa binotata (Say).

(Pl. VI, figs 11, 12.)

Membracis binotata Say, Long's 2nd Exped., ii, p. 301, 1824; Compl. Writ., 1, p 201
Enchophyllum binotatum Fitch, Homop N. Y. St. Cab, p. 47, 1851
Enchenopa binotata Walker, List Homop, ii, p 481, 1851.
Enchenopa brevis Walker, List Homop., ii, p. 492, 1851.
Thelia binotata Emmons, Nat Hist. N. Y. Ins., p. 156, 1854.
Enchenopa bifusifera Walker, List Homop, Suppl., p. 125, 1858.
Enchenopa bivittata Rathvon in Mombert's Hist. Lanc. Co, Pa., p 551, 1869
Enchenopa porrecta Buckton, Monog. Membr, p. 51, pl 6, fig. 5, 1902

Funkhouser gives the following technical description:

Much resembling the preceding species in size and in general appearance, but differing in shape of the head, in shape of sculpturing of the pronotal horn, and in bearing two yellow spots on the dorsal line of the pronotum.

Head longer than broad, uniform brown, finely but densely punctate, sparingly pubescent; eyes prominent, very deep brown; ocelli yellowish, farther from each other than from the eyes; clypeus longer than broad, rounded at tip, not punctate.

Prothorax finely punctate, sparsely pubescent; two distinct ridges on each side, the upper extending to the lateral margin; pronotal horn strongly curved, broadly foliaceous above, triquetrate at tip; median dorsal carina high and percurrent; two dorsal spots of lemon yellow, the anterior about twice as long as the posterior; posterior process gradually acuminate, extending slightly beyond internal angles of tegmina.

Tegmina concolorous brown, opaque, costal margins slightly punctate, and feebly pubescent at base, veins distinct, five apical and one discoidal cell First two pairs of legs broadly foliaceous; hind tibiæ spined; tarsi thin

Length 5 mm; width 2 mm.

Internal male genitalia. Styles stout, anterior portion longer and broader than posterior, with a rounded prominence to connective, wider just caudad of this, apices strongly hooked and truncate, the apical point being slightly longer than the anterior one, with a few hairs on the terminal third; connective heart-shaped, broad, a basal V-shaped band heavily chitinized; œdagus, viewed laterally, strongly curved, base very wide and extending dorsad in a large rounded prominence which is separated by a broad notch from the pointed attachment to the connective, the apex pointed and with functional orifice below the tip, the dorsal surface of which bears a number of filelike teeth.

Distribution. Van Duzee reports this species from Ontario, Massachusetts, New Hampshire, New York, New Jersey, Pennsylvania, Maryland, District of Columbia, North Carolina, Florida, Illinois, Iowa, Michigan, Kansas, Missouri and Texas. In Kansas specimens are reported from Douglas, Riley, Sedgwick, Bourbon and Pottawatomie counties.

Fowler records it from Mexico, Guatemala and Panama. It is thus seen to occur throughout the eastern United States and down through Central America.

Hosts. Funkhouser gives the following hosts: Locust, wild grape, bittersweet, hickory, sycamore, butternut, dogwood, daisy, joe-pye weed Miss Branch adds golden rod and pin oak. Matausch gives *Viburnum.* Goding records it from butternut, birch, apple, walnut, grape, hop tree, locust, redbud, cherry, *Viburnum*, *Ceanothus* and white birch. The writer has taken it chiefly on locust, *Ceanothus* and walnut.

SUBFAMILY SMILIINÆ (Stal).

This subfamily includes all but the three preceding members of our fauna. In all of them the pronotum conceals the scutellum and the tibiæ are not foliaceous. The seventeen genera occurring in Kansas may be separated by the following key:

KEY TO GENERA

A. Tegmina entirely free, not covered by pronotum.
- B. Veins of corium closely united at base
  - C. Suprahumeral horns present. — *Ceresa*
  - CC. Suprahumeral horns absent — *Stictocephala*
- BB. Veins of corium widely separated at base.
  - C. Tegmina with five apical cells; veins distinct. — *Acutalis.*
  - CC. Tegmina with four apical cells; veins indistinct. — *Micrutalis.*

AA. Tegmina partly or entirely covered by pronotum.
- B. Terminal cell of hind wing sessile, its base truncate.
  - C. Pronotum without horn or crest
    - D. Dorsum low and rounded. — *Carynota.*
    - DD. Dorsum high, compressed, and foliaceous. — *Archasia.*
  - CC Pronotum with horn or crest.
    - D. Horn anterior and porrect. — *Thelia.*
    - DD Horn a flat dorsal crest.
      - E. Crest arising from between humeral angles. — *Glossonotus.*
      - EE Crest arising from behind humeral angles.
        - F. Crest strongly step-shaped. — *Heliria.*
        - FF. Crest sometimes slightly, but not usually step-shaped
          - G Basal costal cell of tegmina not entirely punctate. — *Telamona.*
          - GG. Basal costal cell of tegmina entirely punctate. — *Telamonanthe.*
- BB. Terminal cell of hind wing triangular and petiolate.
  - C. Base of corium with three veins.
    - D. Corium without cross-veins at base. — *Smilia.*
    - DD. Corium with cross-veins at base.
      - E. Dorsum strongly compressed. — *Cyrtolobus.*
      - EE. Dorsum rounded. — *Ophiderma.*

CC. Base of corium with two veins.
- D. Apical cell of tegmina transverse. *Vanduzea.*
- DD. Apical cell of tegmina triangular.
  - E. Dorsum strongly elevated, with deep median notch. *Entylia.*
  - EE. Dorsum slightly elevated, with weak median depression. *Publilia*

GENUS CERESA Amyot & Serville.

To this genus belong our commonest species, most of which are green and all of which are at once recognized by their prominent suprahumeral horns.

The seven species known to occur in Kansas may be separated by the following key:

KEY TO SPECIES

A. Species brown
- B. Species larger and very hairy; suprahumerals not recurved, one white band on posterior process. *diceros.*
- BB. Species smaller, with few hairs, suprahumerals recurved; two white bands on posterior process *albescens.*

AA. Species green.
- B. Dorsal crest marked with brown or reddish.
  - C. Suprahumerals short and slightly recurved. *palmeri*
  - CC. Suprahumerals longer and strongly recurved *constans*
- BB. Dorsal crest concolorous.
  - C. Species small, 7-8 mm. long
    - D. Very hairy species *borealis.*
    - DD. Sparsely haired species *brevicornis*
  - CC. Species large, 8-10 mm long.
    - D. Suprahumerals long, sloping upward and recurved; clypeus much produced beyond vertex. *taurina*
    - DD. Suprahumerals stout, nearly straight, clypeus short *bubalus.*

Ceresa diceros (Say).

(Pl III, figs. 1, 2.)

Membracis diceros Say, Long's 2nd Exped., ii, p 299, 1824; Compl Writ., i, p 199
Smilia diceros Germar, Silb Rev Ent, iii, p 237, 1835
Ceresa postfasciata Amyot & Serville, Hem., p 540, pl 10, fig 3, 1843
Ceresa diceros Fairmaire, Ann Soc Ent Fr, ser 2, iv, p 285, 1846
Ceresa vitidalis Buckton, Monog Membr., p 172, pl. 36, figs 3-3b, 1903.

Funkhouser gives the following technical description:

Dark brown with transverse bands of yellowish white; suprahumeral horns stout and blunt; posterior process decurved; tegmina smoky hyaline.

Head broader than long, sculptured, basal part strongly and smoothly curved, front surface light yellow faintly marked with brown, faintly longitudinally ridged, very slightly or not at all punctate or pubescent; eyes prominent, extending beyond adjoining lateral margin or pronotum; ocelli shining, transparent, nearer to each other than to the eyes; sclerites of front

projecting over clypeus at internal angles with a small hook; clypeus strong, swollen, roughly three-lobed, the central lobe the largest, tips strongly hirsute.

Pronotum densely and coarsely punctate; anterior surface slightly convex, light yellow with numerous brown markings, sparingly pubescent with rather long hairs; suprahumeral horns projecting outward and very slightly backward; lateral surfaces not pubescent, brown with two transverse light bands, the anterior broad and irregular in about center, the posterior narrower and regular just before apex of posterior process; posterior process gradually acute, extending beyond internal angles of tegmina.

Tegmina hyaline, tips smoky, bases opaque and lightly punctate; five apical and three discoidal cells. Undersurface of body very dark brown. Femora dark brown above; tibiæ and tarsi ferruginous.

Length, 9 mm.; width between humeral horns, 5.5 mm.

Internal male genitalia. Styles stout, varying much in the length of the cephalic part which, at its greatest length, is shorter than the part caudad of the connective, the sharply pointed caudal portion bearing two rows of long hairs; connective longitudinally keeled, when open nearly twice as long as wide, base concave, apex narrowed but obtuse; œdagus, viewed laterally, much as in *Ceresa bubalus*, but with dorsal process usually more pointed apically and the ventral process distinctly narrower and more acute apically.

Distribution: Van Duzee reports this species from Nova Scotia, Ontario, New York, New Jersey, Pennsylvania, Maryland, North Carolina, Ohio, Illinois, Iowa, Kansas, Missouri, Dakota, Colorado, Texas, New Mexico and Montana. It is therefore one of our most widely distributed species. In Kansas specimens have been taken in Douglas, Miami, Neosho, Bourbon, Pottawatomie, Riley, Shawnee and Saline counties.

Hosts: The usual host for this species is elderberry. Funkhouser gives the following additional hosts: Locust, oak, sycamore, sweet clover, blackberry and butternut.

Ceresa albescens Van Duzee.

Ceresa albescens Van Duzee, Bul Buf Soc Nat Sci, ix, p. 35, 1908.
Ceresa bubalus var. *a* and *b* Fitch, Homop. N Y St Cab., p. 50, 1851.

The following is the original description:

A little smaller and paler than *diceros*, to which it is closely allied. Pronotum as in *diceros*, but with the suprahumeral horns more acute and recurved and tipped with black, and the apex longer and more slender. Face, front and superior surface of the pronotum greenish- or yellowish-white with scarcely a trace of the maculations found in *diceros*; apex of the head less produced, the tylus scarcely longer than the cheeks. Sides of the pronotum paler, ferruginous, becoming somewhat fuscous posteriorly, irrorate with paler and marked with a pale marginal line and sometimes with an oblique median vitta; protracted apex whitish with a black tip and ferruginous median vitta; outer surface of the suprahumerals dark ferruginous, differentiated from the

ferruginous sides by the pale lateral line which nearly attains the apex of the horns. Legs and beneath ferruginous, the femora darker. Last ventral segment of the female a very little oblique and rounded to the median notch, which is triangular, acute, and reaches the middle of the segment. Plates of the male not attaining the apex of the anal tube Elytra almost hyaline, not smoky brown as in *diceros*, nervures ferruginous. Length, 8-9 mm.

Distribution. Van Duzee reports this species from Ontario, New York, and Kansas. Matausch took specimens in New Jersey. The Kansas specimens were taken at Effingham, Atchison county.

Hosts. Matausch gives *Viburnum* as a host.

Ceresa palmeri Van Duzee.

(Pl III, figs 3, 4)

Ceresa palmeri Van Duzee, Can. Ent., xl, p 114, 1908

Funkhouser gives the following technical description:

Near *Ceresa constans*, but differing particularly in shape of the suprahumeral horns, which are short, terete, and but little recurved; small, reddish species, with pronotum rather high, not pubescent.

Head wider than long, yellowish, only faintly sculptured, not punctate; eyes prominent, reddish with white borders, extending beyond adjoining lateral margins of pronotum; ocelli not prominent, pearly with reddish margins, nearer to each other than to the eyes, clypeus continuing lateral margin of face, swollen and pubescent at tip.

Pronotum yellow-green, very strongly marked with brown and reddish; dorsal crest curved, strongly marked with red; lateral semicircular impression faint, area within it lighter in color than surrounding pronotum; posterior process slightly curved downward, about reaching tip of abdomen but not extending halfway to extremities of tegmina.

Tegmina hyaline, wrinkled, bases slightly punctate. Undersurface of body yellowish. Legs concolorous yellow-green in life, fading to pale yellow in cabinet specimens.

Length, 8 mm ; width, 3.5 mm.

Internal male genitalia. Styles large and stout, widest just caudad of attachment to connective, then broad until suddenly narrowed to the acute apex, caudal third with a fringe of long hairs extending nearly to the apex on the outer margin, but stopping considerably cephalad of the apex mesally; connective elongate heart-shaped; œdagus, viewed laterally, with dorsal process of medium width, ventral process more heavily chitinized and quite stout until near the quite acute apex, the membrane guarding the functional orifice large and about midway between the base and apex of the process.

Distribution. Van Duzee reports this species from Ontario, New York and North Carolina. Specimens have been taken in Kansas in Linn, Bourbon, Hodgeman and Cowley counties.

Hosts. Funkhouser gives young hickory as a host, while Metausch took numerous nymphs of the species from *Liquidambar*.

Ceresa constans (Walker).

Thelia constans Walker, List Homop., ii, p. 563, 1851
Ceresa constans Stal, Of. Vet. Akad. Forh., xxvi, p. 245, 1869
Ceresa subulata Provancher, Pet. Faune Ent. Can., iii, p. 338, 1890
Ceresa illinoiensis Goding, Bul. Ill. St. Lab. Nat. Hist., iii, p. 404, 1894

Funkhouser gives the following technical description:

Small and distinctly reddish, dorsal crest low, median lateral line red; metopidium convex; horns sharp and much recurved; posterior process nearly straight, usually tipped with red; head triangular; tegmina and wings hyaline.

Head subtriangular, weakly sculptured, faintly longitudinally furrowed, very finely and lightly punctate, not pubescent; eyes prominent, dark brown with lighter edges, extending beyond adjoining lateral margins of pronotum; ocelli glassy, nearer to each other than to the eyes; clypeus much longer than wide, extending for more than half its length beyond lateral margin of face, tip hirsute.

Pronotum deeply and coarsely punctate, not pubescent, median carina prominent; dorsal crest low, rising but little higher than tips of suprahumeral horns; horns slender, sharp, much recurved, extending upward and curving backward; metopidium convex, regular; lateral semicircular impression deep, concolorous; posterior process nearly straight, not reaching the extremity of the abdomen and reaching barely one-third the distance to the tips of the tegmina.

Tegmina hyaline. Undersurface of body and legs yellowish.

Length, 8 mm.; width, 4 mm.

Distribution. Van Duzee reports this species from Ontario, New York, North Carolina and Illinois. Specimens have also been taken in Riley county, Kansas.

Hosts. Funkhouser gives locust as the host.

Ceresa borealis Fairmaire.

(Pl. III, figs. 7, 8.)

Ceresa borealis Fairmaire, Ann. Soc. Ent. Fr., ser. 2, iv, p. 281, 1846.

Funkhouser gives the following technical description:

Resembling *C. bubalus* in general outline, but much smaller and very hairy; metopidium convex; dorsum curved, posterior process only slightly decurved; head impunctate; notch of last ventral segment of female broad and triangular.

Head broader than long, yellowish, roughly sculptured, faintly longitudinally striate, not punctured nor pubescent; eyes prominent, mottled with green and brown, extending beyond adjoining lateral margins of pronotum; ocelli small, reddish, much nearer to each other than to the eyes; clypeus rounded, somewhat protruding, extending for more than half its length below lateral margin of face, tip hirsute.

Pronotum green, finely, deeply and densely punctate, very hairy; metopidium convex; median carina faint; suprahumeral horns stout, blunt, nearly

straight, projecting almost directly outward; dorsal crest regularly arcuate; lateral semicircular impression nearly obsolete; posterior process curving slightly downward, not extending beyond tip of abdomen and reaching only for a short distance beyond internal angles of tegmina.

Tegmina entirely hyaline, somewhat wrinkled, bases lightly punctate. Legs and undersurfaces of body concolorous greenish.

Length, 8 mm.; width, 4 mm.

Internal male genitalia. Style very large when compared with the other members of the genus, anterior process short, a small but distinct knob to the connective, posterior portion extending straight until considerably past the connective, then bending rather abruptly laterad and ending in a tip that on its mesal margin bears a number of small but distinct teeth; connective very long and rather slender, notched at base; œdagus, viewed laterally, small, with dorsal process strongly humped, the ventral process with basal knob, then tapering regularly to acute tip, membrane around functional orifice at middle third.

Distribution. Van Duzee records this species from Ontario, New York, New Jersey, Pennsylvania, North Carolina, Ohio, Kansas, Colorado, and Utah. In Kansas specimens have been taken in the following counties: Cowley, Sumner, Bourbon, Cherokee, Chautauqua, Douglas, Riley, Shawnee, Crawford, Miami, Linn, Neosho, Rawlins, and Ottawa It is thus seen to extend well over the state.

Hosts. Funkhouser gives the following host list for this species: Wild grape, locust, elder, willow, oak, hickory, pignut, raspberry, sycamore, apple, and pear.

Ceresa brevicornis Fitch.

Ceresa brevicornis Fitch, Trans. N. Y St. Agr. Soc., xvi, p 451, 1856.

The following is the original description:

This is so similar to the common Buffalo tree hopper that it will scarcely be distinguished from it except by a practiced eye, although it is undoubtedly a distinct species It differs from that in having the horns much more short, and the sides of the thorax when viewed in front are not gradually curved outwards, but are straight or rectilinear, with the horns abruptly projecting from the corner at the upper end of this line. The acute spine at the tip of the thorax is also more long and slender. The thorax between the horns is slightly convex. The dried specimen is of a pale dull yellow color freckled with faint pale green dots and with a paler straw-colored stripe, quite distinct, upon the angular sides of the thorax from each eye upward to the horn and from thence to the summit of the thorax.

Length of the female, 0.36.

It was met with upon hickory bushes in New Jersey.

Distribution. Van Duzee reports this species from Ontario, Connecticut, New York, New Jersey, Pennsylvania, Ohio, and Illinois. A single specimen taken at Kansas City, Mo., and determined by Dr. E. D. Ball, evidently puts this species within our range.

Hosts. Van Duzee gives basswood as a host.

Ceresa taurina Fitch.

(Pl. II, figs. 3, 4.)

Membracis taurina Harris, List Ins. Mass in Hitchcock, Geol. Mass., p. 579, 1833 (MS name).

Enchenopa taurina Walker, List Homop., ii, p. 495, 1851 (MS name).

Ceresa taurina Fitch, Trans. N. Y. St. Agr. Soc., xvi, p. 335, 1856.

Funkhouser gives the following technical description:

Slightly smaller than *C. bubalus*, but resembling it in color; body slender and metopidium concave transversely; horns sharp, curving upward and backward.

Head roughly triangular, wider than long, roughly sculptured, not punctate nor pubescent, basal margin strongly curved; eyes prominent, brown and in some cases barred with darker, extending beyond the adjoining lateral margins of the pronotum; ocelli prominent, pearly, occasionally margined with reddish, nearer to each other than to the eyes; clypeus subrectangular, swollen and protruding, extending for half its length beyond lateral margin of face, faintly trilobed, apex bristled.

Pronotum deeply and coarsely punctured, bright green fading to yellow, sparingly pubescent; metopidium strongly concave, with curved, transverse margin, area above eyes smooth; suprahumeral horns slender and sharp, extending upward and backward, often much curved, tips generally darker than bases; dorsal crest high and strongly curved; semicircular lateral impression deep and brownish; posterior process slender, strongly decurved, extending beyond apex of abdomen and halfway to tips of tegmina.

Tegmina and wings entirely hyaline. Underparts of body and legs yellow-green.

Length, including tegmina, 9 mm.; width between tips of horns, 5.5 mm.

Internal male genitalia. Styles with anterior part weak, strongly narrowed near middle of connective, then much widened into the large posterior portion, which ends in an oblique and serrate tip, both margins of the caudal half of the posterior portion bearing long hairs; connective long and rather narrow, folding longitudinally, and with the usual basal incision; œdagus, viewed laterally, with basal process long and slender, with a distinct knob at point of attachment to the connective, the ventral process rather narrow, tapering gradually to subacute tip, functional orifice covering the middle third of the ventral side.

Distribution. Van Duzee reports this species from Ontario, Massachusetts, New York, New Jersey, Pennsylvania, Virginia, North

Carolina, Ohio, Michigan, Iowa, Kansas, Colorado, and Arizona. Specimens have been taken in Kansas in Sumner, Hodgeman, Douglas, Riley, Shawnee, Ottawa, Linn, Cherokee, Bourbon and Miami counties.

Hosts. Funkhouser reports this species from the following hosts: Raspberry, hickory, potato, blackberry, dahlia, hazelnut, locust, witch hazel, blue grass, oak, pear, apple, sweet clover, and bittersweet. Miss Branch adds horseradish and choke cherry. Matausch mentions *Solidago.*

Ceresa bubalus (Fabricius).

(Pl II, figs. 1-2 and 5-8)

Membracis bubalus Fabricius, Ent Syst , iv, p. 14, 1794.
Centrotus bubalus Fabricius, Syst Rhyng., p. 20, 1803.
Ceresa bubalus Fitch, Homop N Y St Cab., p. 50, 1851.

Funkhouser gives the following technical description.

Bright green fading to yellowish in cabinet specimens; horns heavy and stout, pointing directly outward; metopidium broadly convex; dorsal crest high and regularly arched; posterior process slender and recurved; tegmina and hind wings entirely hyaline; clypeus heavy, stout, and bristled.

Head one-third broader than long, longitudinal striate sculpturing; basal part broadly curved, front surface yellow, not punctate nor pubescent; eyes prominent, dark brown, extending beyond lateral margin of pronotum adjoining; ocelli prominent, protruding, with brilliant orange borders, nearer to each other than to the eyes; clypeus strong, heavy, continuing lateral outline of face, apex bristled.

Pronotum densely and coarsely punctate; metopidium strongly convex, smooth impunctate areas above the eyes, sparingly pubescent with short scattered hairs; suprahumeral horns stout, blunt, projecting almost directly outward, not at all upward, tips often brownish, whitish line extending backward from tip to lateral margin; lateral surface marked with light-colored semicircular impression; posterior process slender, depressed, extending half way to apices of tegmina and slightly beyond tip of abdomen, apex brownish.

Tegmina hyaline, bases lightly punctate. Undersurface of body yellowish. Legs greenish.

Length to apices of tegmina, 10 mm.; width between horns, 6 mm.

Internal male genitalia. Styles seemingly varying considerably in size, usually large, the anterior portion about as long as the posterior, which ends in a sharp point which is usually perfectly smooth, but sometimes bears a few indistinct teeth, the margins with two rows of hairs of which the outer one is longer and consists of longer hairs; connective about oval in outline, the base incised and with a distinct tendency to fold along a longitudinal keel; œdagus, viewed laterally, with the dorsal process varying from rather slender and straight to quite stout and hunch-backed, the

ventral process of medium thickness, the apex acute and with the usual membrane around the functional orifice near the middle third.

Distribution. This species occurs throughout the United States as shown by the following records of its distribution given by Van Duzee: Nova Scotia, Ontario, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, Maryland, Delaware, North Carolina, Tennessee, Ohio, Indiana, Illinois, Iowa, Minnesota, Kansas, Missouri, Dakota, Montana, Wyoming, Colorado, Utah, New Mexico, Texas, and California.

As far as our collecting in this state shows, this species is by far the most widely distributed, specimens having been taken in the following counties: Douglas, Wilson, Riley, Comanche, Russell, Butler, Pawnee, Finney, Graham, Rawlins, Cherokee, Wallace, Harper, Shawnee, Wyandotte, Allen, Decatur, Harvey, Saline, Neosho, Sumner, Reno, Hodgeman, Osborne, Labette, Anderson, Pottawatomie, Wabaunsee and Ottawa.

Hosts. The list of plants on which this species feeds is very large, including many weeds and trees. Funkhouser records it from the following hosts: Sycamore, aster, poplar, potato, butternut, hazelnut, pear, sumac, oak, locust, elm, willow, elder, sweet clover, hickory, pignut, apple. Miss Branch reports it from osage orange, horseradish, gama grass, sunflower and alfalfa. Goding records it from apple, potato, tomato, pear, peach, plum, grape, apricot, almond, willow, locust and Japanese lily. Gillette and Baker report it from willow, apple, soft maple, *Solidago spectabilis, Aster canescens, Apocynum androsæmifolium, alfalfa, and Glycrrhiza lepidota.* The writer has taken it most frequently on apple, locust, hickory, sweet clover and alfalfa in Kansas.

GENUS STICTOCEPHALA Stal.

The members of this genus are greenish species, which differ from those of the preceding genus by lacking the suprahumeral horns.

The three species occuring in Kansas may be separated by the following key:

KEY TO SPECIES.

A. Carinate sides of the metopidium meeting before the middle of the body. *inermis.*

AA. Carinate sides of the metopidium meeting at or behind the middle of the body.

- B. Carinate sides of the metopidium meeting at or near middle of dorsum. *lutea.*
- BB. Carinate sides of metopidium meeting much behind middle of dorsum. *festina.*

Stictocephala inermis (Fabricius).

(Pl. IV, figs 1, 2, and 5-8.)

Membracis inermis Fabricius, Syst. Ent., p. 677, 1775
Cicada inermis Gmelin *in* Linnaeus, Syst. Nat., edn. 13, i, pt. 4, p. 2093, 1788
Centrotus inermis Fabricius, Syst. Rhyng., p. 21, 1803.
Membracis gonophora Say, Jl. Acad. Nat. Sci. Phila., vi, p. 243, 1830, Compl. Writ., ii, p. 377.
Smilia inermis Fitch, Homop. N. Y. St. Cab., p. 48, 1851
Ceresa gonophora Walker, List Homop., iv, p. 1141, 1851
Thelia inermis Walker, List Homop., iv, p. 1142, 1851 (under *lutea*)
Stictocephala inermis Stal, Of. Vet. Akad. Forh., xxvi, p. 246, 1869
Stictocephala sanguino-apicalis Goding, Bul. Ill. St. Lab. Nat. Hist., iii, p. 408, 1894.

Funkhouser gives the following technical description:

Fine large species, brilliant green, slowly fading to yellowish in dried material; metopidium perpendicular; dorsal crest high and arcuate; posterior process slender and curving downward; tegmina and wings entirely hyaline, upper parts of femora often marked with black.

Head broad, nearly smooth, very finely and faintly punctate, longitudinally striate; eyes prominent, subtriangular, very dark bordered with white, extending beyond adjoining lateral margins of pronotum; ocelli prominent, brownish, nearer to each other than to the eyes, inferior margins of vertex broadly sinuate; clypeus broad, sparingly pubescent, median lobe of apex extending below lateral lobes.

Pronotum densely and coarsely but not deeply punctured, metopidium convex, median carina distinct but irregular, sides of metopidium meeting before middle of body; lateral semicircular impression deep; posterior process long, slender, gradually acuminate, curving downward, extending beyond abdomen and reaching about halfway from internal angles to apices of tegmina.

Tegmina entirely hyaline, slightly wrinkled, bases greenish and lightly punctured. Undersurface of body yellowish; segments of abdomen in some cases bordered with black; notch of last ventral segment of female broadly angular. Femora often marked with black above; tarsi ferruginous.

Length to tips of tegmina, 9 mm; width between humeral angles, 4 mm.

Internal male genitalia. Styles large and stout, the anterior portion long and wide, the posterior part curving to the truncate and serrate tips, which vary from nearly transversely truncate to quite obliquely truncate, the apex in the latter case being quite pronounced, the posterior fourth with two rows of very long hairs, the outer row being longer; connective short, widest just behind the middle, usually pentagonal in shape; œdagus, viewed laterally, much as in *Ceresa*, the dorsal process varying in width and with a small to a very pronounced hump, but with no projection to the connective, ventral process moderately stout, slightly concave on ventral side preapically, the functional orifice occupying nearly half its length medially.

Distribution. This species is found throughout the United States

as shown by the following distribution given by Van Duzee: Ontario, New York, New Jersey, Pennsylvania, North Carolina, Ohio, Illinois, Iowa, Dakota, Kansas, Missouri, Colorado, New Mexico, Arizona, California, and Montana.

In Kansas it has been taken in the following counties: Chautauqua, Douglas, Hodgeman, Cowley, Ottawa, Riley, Dickinson, Linn, Ellis, Bourbon, Montgomery, and Wabaunsee.

Hosts. Funkhouser records this species from sweet and red clover, timothy and apple. Miss Branch mentions gama grass. Goding reports it from plum, oats, oak and alfalfa. The writer has taken it very commonly on apple.

Stictocephala lutea (Walker).

Thelia lutea Walker, List Homop., ii, p. 559, 1851
Thelia inermis Walker, List Homop., iv, p 1142, 1851.
Gargara pectoralis Emmons, Nat Hist N. Y. Ins., p. 157, p 1, 13, fig. 12, 1854.
Stictocephala lutea Stal, Of. Vet. Akad Forh., xxvi, p. 247, 1869.

Funkhouser gives the following technical description:

Small species; grass-green above, usually marked with black below; metopidium sloping, dorsal crest not high, not regularly arcuate; tegmina smoky hyaline.

Head perpendicular, subtriangular, broader than long, finely punctate, sparingly pubescent, weakly sculptured, eyes prominent, brown usually banded with reddish, extending outward as far as lateral angles; ocelli distinct, yellowish margined with brown, much nearer to each other than to the eyes; inferior margins of vertex weakly sinuate, their ventral mesal angles ending in hooks; clypeus robust, extending only slightly beyond inferior margins of vertex.

Pronotum closely and deeply punctate; metopidium convex, median carina faint, smooth yellowish area on each side near base of head, sides of metopidium meeting at or a little before middle of body; dorsal crest not high, sloping gradually from junction of carinate edges of metopidium to posterior process; semicircular lateral impression weak; posterior process slender, gradually acute, extending as far as tip of abdomen and to a point on tegmina halfway between internal angles and apices.

Tegmina hyaline, smoky at apices. Under parts of thorax distinctly black. Legs generally marked with black. Notch of last ventral segment of female very small or obsolete.

Length, 6.5 mm.; width, 2 mm.

Internal male genitalia. Styles stout, especially posterior portion, bent in near middle of connective, then flaring widely till just before the incurved tips, which are transversely truncate with the inner angle prominent and distinctly serrate on both its margins, the apical fourth of the styles bearing on each margin a row of long hairs; connective large, elongate, widest just caudad of the middle; œdagus, viewed laterally, with medium-sized and humped dorsal

process, the ventral process with a distinct tubercle to connective and wide till the end of the functional orifice, then suddenly narrowed, after which it is nearly parallel-margined to the apex.

Distribution. Seemingly most abundant in the eastern United States as shown by the following records given by Van Duzee: Ontario, Connecticut, New York, New Jersey, Pennsylvania, District of Columbia, North Carolina, Georgia, Florida and Illinois. There are specimens of this species in the Snow collection from Beaver Creek, Montana, thus extending its range westward.

The following Kansas counties have yielded specimens: Linn, Montgomery, Neosho, Riley and Douglas.

Hosts. Matausch reports this species from *Solidago;* Funkhouser from oak and daisy; Goding from wheat.

Stictocephala festina (Say).

(Pl. III, figs. 5, 6.)

Membracis festina Say, Jl. Acad. Nat. Sci. Phila., vi, p. 243, 1830, Compl. Writ., ii, p. 377

Stictocephala festiva Walker, List Homop., iv, p. 1141, 1852.

Stictocephala uniformis Stal, Hemip. Fabr., ii, p. 24, 1869.

Stictocephala festina Stal, Of. Vet. Akad. Forh., xxvi, p. 246, 1869.

The following is the original description:

Thorax with a subacute line each side before, meeting behind the middle.

Inhabits Florida.

Body yellowish-green; thorax unarmed, carinate behind; at tip attenuated, subulate and complying with the general curvature; each side before a carinate line, meeting together at the carina behind the middle, with the carina tinged with rufous; front of the thorax not altogether flat, but a little convex; hemelytra, three terminal cellules unequal; the two costal ones equal, as broad as long; the inner one not obviously larger than the others together, somewhat longer than broad. Length to tip of hemelytra one-fifth of inch. The lateral prominent lines of the unarmed thorax, separate this species from all those I have described excepting gomphera, which meet before the middle of the length of the back.

Internal male genitalia. Styles quite small, anterior portion smaller than posterior, converging posteriorly to the wide posterior portions, which, opposite the connective, have a distinct lateral angle and then narrow but slightly to the obtuse apices, each bearing a long outer row and a short mesal row of stout hairs; connective quite small and triangular; œdagus, viewed laterally, quite characteristic, the dorsal process ending in a large rounded lobe which bears a small, fingerlike terminal process, the ventral process ending in a swollen and obliquely truncate apex which bears the functional orifice.

Both the styles, connective and œdagus of this species are so entirely different from the corresponding parts in the two preceding species that it does not seem possible that they could be members of the same genus.

Distribution. This species occurs abundantly in the Southern states and in more limited numbers as far north as Connecticut, and Canada in the East and Montana in the West. It has been reported from Florida, Virginia, Pennsylvania, Georgia, Missouri, Texas, Iowa, Montana, Colorado, New York, Connecticut, New Jersey, Ottawa, Can., Utah, Arizona, Mississippi, Tennessee, Alabama, North Carolina, Louisiana, Kansas, Iowa, Lower California, Mexico, and the West Indies.

Hosts. Wildermuth records this species from the following hosts: Alfalfa, cowpeas, tomato, almond, Bermuda grass, Johnson grass, wheat, barley, oats, bur clover, yellow sweet clover, soy beans, red clover, vetch, *Hordeum murinum*, beans, sunflower, cocklebur, *Erigeron canadensis*, mesquite, cottonwood, *Sporobolus airodes* and *Trichlaris mendocina.*

GENUS ACUTALIS Fairmaire.

In this genus are small species with the prothorax dark and with five apical cells in the tegmina, the veins of which are quite distinct.

A single species is reported from Kansas.

Acutalis tartarea (Say)

(Pl. V, figs. 5, 6.)

Membracis tartarea Say, Jl. Acad. Nat. Sci. Phila., vi p. 242, 1830; Compl. Writ., ii, p. 376.

Ceresa tartarea Walker, List. Homop., iv, p. 1141, 1852.

Acutalis tartarea Uhler, Bul. U. S. Geol. Geog. Surv., i, p. 345, 1876.

Ceresa semicrema Provancher, Pet. Faune Ent. Can., iii, p. 235, 1886.

Funkhouser gives the following technical description:

Small elongate species, very black, with eyes, undersurface of body and in some cases lateral margins of pronotum white, apices of tegmina abruptly hyaline.

Head twice as broad as long, densely black, smooth, not punctate nor pubescent; eyes prominent and white; ocelli small, white, about equidistant from each other and from the eyes; clypeus foreshortened, smooth, extending only slightly in a semicircular curve below inferior line of face.

Pronotum intensely black above, finely punctate, not pubescent, lateral margins and tip of posterior process in some cases marked with white; dorsal crest low, weakly convex; posterior process nearly straight, slightly decurved, more or less tectiform, extending beyond abdomen and almost to end of apical cells of tegmina, but not reaching apex of hyaline border.

Tegmina opaque black for basal two-thirds, apical third suddenly hyaline;

veins heavy and black; wide apical border; basal third punctate. Undersurface of body pale. Legs yellowish, tarsi fuscous.

Length to apices of tegmina, 4.5 mm.; width between humeral angles, 2 mm.

Internal male genitalia. Styles small, anterior portion slender, then wide opposite connective and narrowing again to the rather slender apical portions, which are strongly hooked, bear a few hairs, and end in an acute apex; connective comparatively large, semicircular; œdagus, viewed laterally, quite large, anterior process smaller and ending acutely, posterior process very large and ending obtusely.

Distribution. Van Duzee reports this species from Ontario, Massachusetts, New York, Pennsylvania, District of Columbia, North Carolina, Florida, Mississippi, Illinois, Iowa, Missouri, Colorado, and Utah. Miss Branch reports it from Douglas county, Kansas.

Hosts. Miss Branch gives *Ambrosia trifida* as a host.

GENUS MICRUTALIS Fowler.

The members of this genus are small and have but four apical cells in the tegmina, the veins of which are very obscure.

A single member of the genus occurs in Kansas.

Micrutalis calva (Say).

(Pl. V, figs. 3, 4)

Membracis calva Say, Jl. Acad. Nat. Sci. Phila., vi, p. 242, 1830; Compl. Writ., ii, p. 376.
Membracis melanogramma Perty, Del. An. Art., pl. 35, fig. 10, 1834.
Smilia flavipennis Germar, Silb. Rev. Ent., iii, p. 240, 1835.
Acutalis flavipennis Fairmaire, Ann. Soc. Ent. Fr., ser. 2, iv, p. 497, 1846.
Ceresa calva Walker, List Homop., iv, p. 1141, 1852.
Acutalis melanogramma Walker, List Homop., ii, p. 591, 1851.
Acutalis calva Fitch, Trans. N. Y. St. Agr. Soc., xvi, p. 391, 1856.
Acutalis illinoiensis Goding, Can. Ent., xxv, p. 53, 1893.
Micrutalis illinoiensis Baker, Can. Ent., xxxix, p. 116, 1907.
Micrutalis calva Baker, Can. Ent., xxxix, p. 116, 1907.

Funkhouser gives the following technical description:

Very minute; one of the smallest species of Membracidæ in the United States; usually strongly marked with black, although color is variable; abdomen yellowish; tegmina hyaline, veins very indistinct.

Head broad, smooth, lightly punctate, not pubescent, upper third black, lower two-thirds yellowish; eyes prominent, white or gray; ocelli not prominent, pearly, about equidistant from each other and from the eyes and situated slightly above an imaginary line drawn through centers of eyes; clypeus rounded, continuing sinuate outline of inferior margin of face.

Pronotum low, nearly flat, finely punctate, not pubescent, anterior part usually black, tip of posterior process generally pale; posterior process stout, triangular, just reaching internal angles of tegmina and not extending as far as tip of abdomen.

Tegmina entirely hyaline, not punctate nor pubescent at base, veins indistinct, apical border broad. Entire abdomen pale; undersurface of thorax often marked with black. Femora black or ferruginous; tibiæ fuscous, tarsi ferruginous.

Length, 3-3.5 mm.; width, 1.5-1.7 mm.

Internal male genitalia. Styles with anterior and posterior parts of about equal length, anterior ends pointed, strongly swollen opposite connective, posterior part curving laterad, with a distinct hook before the acute apex, and with about a dozen hairs along the lateral margin; connective small, notched basally, widest at the truncate apex; œdagus, viewed laterally, U-shaped, the base nearly straight and with a large process to connective, functional orifice along the side of the posterior arm which bears numerous sawlike teeth on its cephalic aspect and a few scattered ones laterally.

Distribution. This is a very widely distributed species occurring throughout the Eastern and Southern states as shown by the following distribution given by Van Duzee: New Hampshire, Massachusetts, New York, Pennsylvania, Maryland, District of Columbia, Virginia, North Carolina, Georgia, Florida, Alabama, Mississippi, Ohio, Michigan, Illinois, Missouri, Kansas, Iowa, Arkansas, Texas, Colorado. It is also known to occur in the West Indies.

Specimens have been taken in the following Kansas counties: Reno, Douglas, Riley, Bourbon, Harper, Chautauqua, Cowley, Cherokee, Allen, Harvey, Montgomery, Butler, Kingman, Sumner, Miami and Ottawa.

Hosts. Funkhouser gives black locust as a host. It is commonly taken when sweeping weeds and grasses in Kansas.

GENUS CARYNOTA Fitch.

The members of this genus have the elytra partially covered by the pronotum, which lacks a horn or crest. The dorsum is low and rounded.

A single species occurs in Kansas.

Carynota mera (Say).

Membracis mera Say, Jl. Acad Nat. Sci. Phila., vi, p. 301, 1831; Compl. Writ., ii, p. 379.
Carynota mera Fitch, Homop N. Y. St. Cab., p. 48, 1851.
Gargara majus Emmons, Nat. Hist. N. Y. Ins., p. 156, pl. 13, fig. 6, 1854.
Ophiderma mera Fitch, Trans N. Y St. Agr. Soc., xvi, p. 465, 1856.
Craynota strombergi Goding, Bul. Ill. St. Lab. Nat. Hist., iii, p. 443, 1894.

Funkhouser gives the following technical description:

Fine large species; gray marked with dark brown and chestnut; pronotum convex and elevated; tegmina fuscous-hyaline tipped with dark brown.

Head nearly twice as broad as long, uniform light gray, very distinctly punctate, sparingly pubescent with short, white hairs; eyes very prominent

and brown; ocelli prominent, pearly, margined with orange, somewhat protruding, nearer to each other than to the eyes; clypeus subtriangular, continuing inferior outline of face, tip produced in small tooth, hirsute.

Pronotum gray, finely punctate, pubescent, median carina percurrent; metopidium convex, irregular brown mark above internal angle of each eye; dorsal line arcuate, suddenly depressed before posterior process in female, depression not so evident in male; wide, dark brown, transverse band crossing middle of pronotum on each side; posterior process heavy, pointed, tip chestnut.

Tegmina smoky hyaline, veins prominent, bases punctate, especially along veins and at costal margins, tips dark brown or black. Legs and undersurface of body ferruginous.

Length: female, 10 mm.; male, 8.5 mm. Width. female, 5 mm.; male 4 mm.

Distribution. Van Duzee reports this species from Ontario, New York, New Jersey, Pennsylvania, North Carolina, Ohio, Illinois, Iowa, Missouri and Texas. The writer took a single specimen in Ottawa county, Kansas.

Hosts. Funkhouser mentions hickory, butternut, pecan and oak as hosts of this species.

GENUS THELIA Amyot & Serville.

The members of this genus are at once recognized by the possession of a long horn on the anterior part of the prothorax, which points upwards and forwards.

Both members of the genus known to occur in the United States are found in Kansas. They may be separated by the following key:

KEY TO SPECIES.

A. Prothorax of male without lateral yellow stripe. *uhleri.*
AA. Prothorax of male with lateral yellow stripe. *bimaculata.*

Thelia uhleri Stal.

Thelia uhleri Stal, Of. Vet. Akad. Forh., xxvi, p. 248, 1869

The original description follows:

Griseo-ferruginea, pilosa, thorace remote pallido-consperso; tegminibus sordide hyalinis, apice fusco-nebulosis, basin versus punctatis. Female: Long. 9; cum cornu, 13. Lat. 4½ mill. Wisconsin. (Mus. Holm.)

T. bimaculatæ maxime affinis, pictura thoracis, ejusdem cornu antico paullo longiore processuque postico rugis longitudinalibus destituto divergit. Caput remote punctulatum. Thorax dense distinctque punctatus, angulis lateralibus nonnihil prominulis, rectis, cornu antico antrorsum valde nutante, processu postico apicem tegminum subattingente.

Ad hanc speciem verisimiliter spectat Fitch, quum dicit *Membracem belligeram* Say ad *Theliam* referendam esse; hæc species autem ad *Platycotem* pertinet et eadem est ac *P. sagittata* Germ., quæ Americam borealem (nec Brasiliam) inhabitat.

Distribution. Van Duzee reports this species from Ontario, New York, Pennsylvania, Michigan, Illinois, Wisconsin, and Kansas.

Hosts. Seemingly unknown.

The writer has not seen specimens of this species, but it is included in this paper because of Van Duzee's records.

Thelia bimaculata (Fabricius).

(Pl. V, figs. 1, 2.)

Membracis bimaculata Fabricius, Ent. Syst., iv, p. 10, 1794.
Hemiptycha binotata Harris, Rept. Ins Mass., p. 179, 1841.
Hemiptycha acuminata Harris, Rept. Ins. Mass., p. 179, 1841.
Thelia bimaculata Amyot & Serville, Hemip., p. 541, 1843.
Thelia unanimis Walker, List Homop., ii, p. 566, 1851.

Funkhouser gives the following technical description:

Female. Gray with indistinct darker irregular markings; porrect cylindrical horn slightly flattened and somewhat darker in color at tip; tegmina hyaline, apices fuscous, almost reaching extremity of dorsal process.

Head, including eyes, twice as broad as long, grayish-yellow mottled with ferruginous and brown; margins of loræ strongly sinuate; eyes dark brown; ocelli white, nearer to each other than to the eyes and situated on a line drawn through centers of eyes; clypeus pilose; beak extending to posterior coxæ; head very sparingly punctate and sparsely pilose.

Thorax gray, deeply and densely punctate; median percurrent brown line sharpened into a ridge on extremity of horn and at apex of posterior process; sides of prothorax roughly and irregularly carinate; horn porrect and greatly variable in length; cylindrical except at extreme tip, where it is flattened laterally; posterior process heavy, tectiform, gradually acute, almost straight, very slightly decurved and extending beyond apices of tegmina.

Tegmina hyaline, apices fuscous, bases and costal regions lightly punctate; underwings hyaline, two-thirds as long as tegmina. Undersurface of body gray-brown, pubescent. Legs uniform yellow-brown; femora thick and smooth; tibiæ and tarsi densely pilose.

Length, 11 mm., including horn, 14 mm.; width between humeral angles, 5.5 mm.

Male: Differs from female in size and markings. Smaller, body somewhat less robust; porrect horn usually shorter and tending to curve; tegmina equalling apex of posterior process. Color deep chocolate brown; porrect horn almost black; apex of posterior process becoming cinnamon brown; a wide, brilliant, lemon-yellow longitudinal stripe on each side of prothorax, extending from margin halfway to median dorsal line, also small patches of yellow on metopidium; head yellow with brown patches. Undersurface of abdomen darker than in female.

Internal male genitalia. Styles with anterior portion short, posterior part longer, wide, and parallel-margined till near apices, which are curved strongly laterad and end truncately but with a distinct recurved hook, the curved apices bearing scattered short hairs; connective large, rather distinctly seven-sided; œdagus, viewed laterally, with a slender process to anal tube, the apical portion

very large, club-shaped, the functional orifice just before the extreme apex, the anterior aspect of the apex with many filelike teeth.

Distribution. Van Duzee reports this species from Ontario, Massachusetts, New York, New Jersey, Pennsylvania, North Carolina, Ohio and Illinois. The writer has taken it in Douglas county, Kansas.

Hosts. Black locust seems to be the only host.

GENUS GLOSSONOTUS Butler.

The members of this genus possess a tongue-shaped crest, which arises from between the humeral angles.

A single species of the genus is recorded from Kansas.

Glossonotus acuminatus (Fabricius).

Membracis acuminata Fabricius, Syst Ent, P 675, 1775
Cicada acuminata Gmelin in Linnæus, Syst Nat, edn 13, i, pt 4, 2094, 1778
Centrotus acuminata Fabricius, Syst Rhyng, p 18, 1803
Thelia acuminata Fairmaire, Ann Soc Ent Fr., ser 2, iv, p 310, pl 5, fig 15, 1846
Hemiptycha acuminata Harris, Treat Ins Inj Veg, edn 3, p 223, 1862
Telamona acuminatus Stal, Hemip Fabr, ii, p 115, 1869
Glossonotus acuminata Butler, Cist Ent, ii, p 222, 1877
Thelia crataegi Smith, Ins N J, p. 441, 1890

Funkhouser gives the following technical description:

Dark gray mottled with brown; dorsal crest high, flattened and swollen at tip; humeral angles prominent and triangular; tegmina hyaline tipped with brown, veins punctured.

Head almost as long as wide, gray with distinct scattered black punctures and fine whitish pubescence; base sinuate; eyes large, prominent, brown, extending as far as bases of humeral angles; ocelli large, prominent, pearly with white margins, nearer to each other than to the eyes; clypeus continuing inferior line of face, punctate with black, pubescent with white, tip prolonged into a point; antennæ long and well developed.

Pronotum dark gray with irregular markings of brown, coarsely and regularly punctate with black, very sparingly pubescent; metopidium convex, median carina prominent and decorated with alternate lines of brown and yellowish, irregular black markings above internal angles of eyes, humeral angles prominent, triangular, flattened, acute; pronotal crest almost as high as length of pronotum, widened and flattened at tip, margin decorated with pale areas, projecting usually forward as well as upward; posterior process gradually acuminate, reaching apices of tegmina.

Tegmina hyaline, tips clouded with smoky brown, bases and margins of veins punctate, veins prominent. Undersurface of thorax fuscous; abdomen ferruginous. Legs fuscous marked with brown.

Length, 10 mm.; width between tips of humeral angles, 6 mm.

Distribution. Van Duzee reports this species from Ontario, Massachusetts, New York, New Jersey, Pennsylvania, Michigan, Iowa, Kansas and Arkansas.

Hosts. Funkhouser gives young white oak as the host.

GENUS HELIRIA Stal.

The members of this genus are characterized by having a distinctly step-shaped dorsal crest.

Two members of the genus are known to occur in Kansas. These Van Duzee separates by the following key:

KEY TO SPECIES

A. Larger, 12-13 mm.; grey or brownish grey; posterior foliole of the crest little elevated above the dorsal line anteriorly, its hind angle subacute; humeral angles greatly produced. *cristata.*

AA Smaller, 8 mm., darker brown; posterior foliole of the crest, when well differentiated, elevated at least its own width above the dorsal line *scalaris.*

Heliria cristata (Fairmaire).

Thelia cristata Fairmaire, Ann Soc Ent Fr, ser 2, iv, p 811, pl 5, fig 14, 1846
Telamona fagi Fitch, Homop N Y St Cab, p 51, 1851
Telamona arcuata Emmons, Nat Hist N Y Ins, p 155, pl 3, fig 5, 1854
Heliria cristata Stal, Of Vet Akad Forh, xxiv, p 556, 1867, xxvi, p 249, 1869
Telamona cristata Fowler, Biol Centr Am, Homop, ii, p 144, pl 9, fig 6, 1896

The following is the original description:

T cristata. Mexique. Long 0 012

Praecedente differt testaceo-obscuro et tuberculorem dispositione, primo antice inclinato, secundo sat fortiter acuto

Ne differe de l espece precedente que par se couleur d'un testace obscue, et la disposition des lobes dorsaux dont l anterieur est incline en avant, et le second plus aigu. Coll Signoret

The preceding species referred to above is *H. scalaris.*

Distribution Van Duzee reports this species from New York, New Jersey, North Carolina, and Illinois Popenoe reports it from Kansas.

Hosts. Unknown

Heliria scalaris (Fairmaire).

Thelia scalaris Fairmaire, Ann Soc Ent Fr, ser 2, iv, p 811, 1846
Telamona fagi Fitch, Homop N Y St Cab, p 51, 1851
Thelia scalaris Walker, List Homop, ii, p 565, 1851
Heliria scalaris Stal, Of Vet Akad Forh, xxiv, p 556, 1867, xxvi, p 249, 1869
Telamona scalaris Butler, Cist Ent, ii, p 222, 1877

Funkhouser gives the following technical description:

A small species, uniform brown in color, crest as high as its length at base; posterior process not reaching apices of tegmina; tegmina smoky hyaline, tips brown

Head as wide as long, sculptured, yellowish, irregularly punctuate with brown, sparingly pubescent; base strongly sinuate; eyes prominent, brown, reaching base of humeral angles; ocelli prominent, translucent, nearer to each other than to the eyes; clypeus extending below inferior margin of face, yellowish, punctured with brown, pubescent

Pronotum uniform brown, coarsely punctured; dorsal crest swollen at base, flattened at apex, as high as its length at base, distinctly step-shaped, anterior

lobe rounded and projecting forward, posterior lobe sharply angular, two-thirds as high as anterior, both lobes in some cases margined with patches of darker brown; posterior process short, heavy, acute, not reaching apices of tegmina; humeral angles triangular, flattened, blunt.

Tegmina smoky hyaline, bases dark brown and punctate, tips brown, veins heavy and often punctured along margins. Undersurface of thorax ferruginous, segments margined with paler; abdomen brown. Legs ferruginous; tibiæ and tarsi hairy.

Length, 8 mm.; width, 4.8 mm.

Distribution. Van Duzee reports this species from Ontario, New York, New Jersey, Pennsylvania, Illinois and Colorado. There is a specimen in the Snow collection from Kansas City, Mo., so it undoubtedly occurs in eastern Kansas.

Hosts. Unknown.

GENUS TELAMONA Fitch.

The following is the original description of the genus:

Humeral angles projecting, pointed and earlike: dorsum compressed-foliaceous, the keel abruptly elevated at one or both its ends, forming a somewhat square crest or foliole; thorax nearly or quite reaching the tips of the elytra, with elevated longitudinal lines on each side; apical cellule triangular, its end rounded. The squarish dorsal crest forms a marked distinction between the genus here proposed, and that of *Thelia,* to which it is most nearly related.

Eleven members of this genus are known to occur in Kansas. These may be separated by the following key:

KEY TO SPECIES.

A. Anterior margin of crest sloping to front of metopidium, without obvious sinus at its anterior base.
- B. Crest, if elevated, more or less rounded or pointed at apex.
  - C. Crest distinctly elevated.
    - D. Brownish species; crest higher and triangular. *pyramidata.*
    - DD. Greenish species; crest an obtusely conical hump. *viridia.*
  - CC. Crest scarcely elevated, broadly rounded above *obsoleta.*
- BB. Crest elevated, square or nearly so at apex.
  - C. Crest not as high as broad.
    - D. Greenish-brown species. *lugubris.*
    - DD. Gray, with oblique brown fascia. *decorata.*
  - CC. Crest as high or higher than broad. *querci.*

AA. Crest nearly vertical before or sometimes overhanging.
- B. Color greenish or yellowish.
  - C. Females bright green; males yellow, banded with brown. *unicolor.*
  - CC. Both sexes of about the same color.
    - D. Pronotal hump very high. *extrema.*
    - DD. Pronotal hump moderate. *collina*

BB. Color not green.

C. Yellow, mottled with brown. *tristis.*

CC. Gray, with transverse brown band. *ampelopsidis.*

Telamona pyramidata Uhler.

(Pl. v, figs. 7, 8.)

Telamona pyramidata Uhler, Wheeler's Rept. Chief Eng. for 1877, p. 1333.
Telonaca pyramidata Ball, Proc. Biol. Soc Wash, xxxi, p. 28, 1918.

Funkhouser gives the following technical description:

Long, narrow body; crest triangular and pyramidal, as the name would suggest; mottled brown with a dark transverse fascia extending from tip of crest to lateral margin of pronotum, and a second shorter fascia behind it; posterior process extending to tips of tegmina; tegmina hyaline, punctate at bases, brown at apices. Differs from *T. declivata* chiefly in shape of dorsal crest.

Head wider than long, yellowish with large irregular punctures of brown, sparingly pubescent; base regularly sinuate; eyes large, prominent, gray; ocelli large, prominent, somewhat protruding, translucent; clypeus subtriangular, sutures distinct, apex slightly produced, hairy.

Pronotum deeply punctate, not pubescent; metopidium convex, decorated with patches of yellowish and dark brown, median carina prominent, heavy, black, broken by circular areas of yellowish; humeral angles prominent, tectiform, blunt, brownish; dorsal crest triangular, rounded at tip, margin flattened and brown, posterior margin pale; posterior process long, slender, slightly curving downward, extending beyond tips of tegmina; median carina percurrent.

Tegmina hyaline, bases and costal margins coarsely punctate but not pubescent, tips brown. Undersurface of thorax flavous; abdomen dark brown. Legs yellowish; tibiæ mottled with brown, hairy; tarsi flavous; claws ferruginous.

Length, 9-11 mm.; width, 5-6 mm.

Internal male genitalia. Styles with anterior portion broad and flat, posteriorly curved outward and with a large, blunt apical hook, the apical fourth with a few short hairs; connective large and heart-shaped, bearing three longitudinal ridges; œdagus, viewed laterally, U-shaped, anterior process rather slender and with a distinct tooth on its cephalic aspect, posterior process large and club-shaped, the apex with sawlike teeth on its anterior surface, and the functional orifice on the posterior.

Distribution. Gillette and Baker report this species from Colorado and Funkhouser from New York. The writer has taken it at Ames, Iowa. Specimens have been taken in Kansas from Johnson, Pawnee, Cherokee, Riley and Pottawatomie counties. It seemingly occurs throughout the Eastern states and west to the Rocky Mountains.

Hosts. Funkhouser reports it on chestnut oak. Gillett and Baker

give cottonwood and Virginia creeper. The writer has taken it abundantly on willow.

The writer has been unable to find any characters that would seem to separate this species from the members of the genus *Telamona.* The genitalia are precisely as in other members of the genus. Hence it is our belief that the genus *Telonaca* should be sunk as a synonym of *Telamona.*

Telamona viridia Ball.

(Pl. VII, figs. 7, 8.)

Telamona viridia Ball, Proc. Biol. Soc. Wash, xvi, p. 178, pl. 1, fig. 3, 1903.

The original description follows:

Resembling *pyramidata* in size and form, but with less of a hump. Grass-green, the male with some fuscous on posterior half of hump and again at apex of pronotum.

Length: female, 11 mm.; male, 9 mm. Width, female, 5.3 mm.

Pronotal hump in the shape of an obtuse pyramid one-third the distance back from eye to apex of pronotum, a slight angle on posterior margin just below apex especially marked in the male. Height of hump slightly less than one-third the pronotal length. Humeral angles broad, slightly rounded, a trifle longer than eye.

Color. Female, grass-green slightly mottled with yellow; carina light except at apex of hump and at tip, where it is tawny. Male, grass-green; carina light interrupted with tawny; a fuscous band runs obliquely backward from apex of hump and fades out before reaching the pronotum proper, or sometimes connects with a tawny spot on lower margin, whole apex of pronotum tawny.

Internal male genitalia. Styles large, anterior end flattened, posterior part stout, curved strongly laterad apically, bluntly hooked, and bearing a few scattered hairs; connective large, heart-shaped, with three longitudinal ridges; œdagus, viewed laterally, U-shaped, anterior arm more lightly chitinized and with short blunt anterior tooth, posterior arm club-shaped, the apex anteriorly with many small filelike teeth, posteriorly with the functional orifice.

Distribution. Ball reports the type specimens from Colorado, Iowa and Illinois. There is a specimen in the Snow collection, taken by F. X. Williams, from Gove county, and a single specimen has been taken in Riley county, Kansas.

Hosts. Ball gives cottonwood (*Populus monilifera*) as the host.

Telamona obsoleta Ball.

Telamona obsoleta Ball, Proc. Biol. Soc. Wash., xvi, p. 178, pl. 1, fig. 2, 1903.

The following is the original description:

Resembling *irrorata*, but smaller and with a smaller and more rounding hump. Length: female, 10 mm.; male, 9 mm. Width, 5 mm.

Dorsal hump low and much inflated; it scarcely narrows from the base to just before the apex where it rounds in to form a carina. Anterior margin rising just back of the humeral angles and extending from there half way to the apex of the pronotum. The height is about equal to the whole length and it rounds down to the pronotum proper at both extremities. Front much elevated above the level of the eyes so that the ocelli are farther from the base of front than from each other.

Color. Yellow with the punctures fuscous, sometimes coalescing into brownish fuscous spots, giving the whole insect an irrorate and mottled appearance, with little regularity of pattern. Usually there is a semicircle of lighter shade back of the humeral angles and a light spot on middle of hump. There is a pair of large, straggling black marks above and within the eyes, some brown on the inner nervures of corium, and a smoky brown cloud at apex.

Distribution. Ball reports this species from Iowa and from Kansas. Van Duzee records it from Illinois and Funkhouser from New York. In Kansas it has been taken in Pottawatomie and Montgomery counties.

Hosts. Ball gives elm as a host; Funkhouser reports it from oak.

Telamona lugubris Ball.

Telamona lugubris Ball, Proc. Biol. Soc. Wash., xvi, p. 179, 1903.

The original description follows:

Form of *reclivata* nearly, slightly shorter and stouter built and with a lower and longer hump and lacking the markings of that species. Obscurely greenish brown. Length: female, 11 mm; male, 9.5 mm. Width, 5.5 mm.

Dorsal hump of moderate size, arising just back of lateral angles; anterior margin sloping back, forming a right angle with the inclined crest, posterior margin perpendicular or slightly overhanging. Base of hump occupying a little over two-fifths of distance from humeral angles to apex of pronotum. Humeral angles blunt and obtuse, about two-thirds as long as the eye.

Color. Pale yellow, the more or less darkened punctures giving the insect a general grayish cast with still darker shadings on the lateral faces of the hump and sometimes on the apex of pronotum.

Distribution. Ball reports this species from Iowa and also from Pottawatomie county, Kansas. Doctor Funkhouser has specimens from New Mexico.

Hosts. Ball gives scrub oak as the host.

Telamona decorata Ball.

Telamona decorata Ball, Proc. Biol. Soc. Wash., xvi, p. 179, 1903.

The original description follows:

Smaller than *lugubris*, with a shorter and more rounding hump. Yellowish fuscous with the hump deep testaceous brown. Length, 9 mm.; width, 4.5 mm.

Dorsal hump sloping up from both front and rear, crest rounding, highest just in front of the middle, hump occupying scarcely two-fifths of the pronotum from the humeral angles back. Humeral angles short and blunt, about two-thirds the length of the eye.

Color. Face and pronotum pale yellow, very slightly washed with brown in the female, and with a definite brown shade in the male; median carina alternately light and dark before the hump. Hump rich testaceous with a few light spots on the sides, a definite light mark at the base in front, which may extend up on to the carina, and the whole posterior margin light. This latter light spot extends down on to the pronotum and connects with an irregular transverse light band about halfway to apex. Each side of this band is an irregular testaceous band, the anterior one connected with the testaceous hump. A pair of spots above the eyes and the apex of elytra brownish fuscous.

Distribution. Ball described this species from specimens taken in Iowa, Arkansas, and Pottawatomie county, Kansas. Funkhouser reports it from New York.

Hosts. Ball mentions red oak as a host.

Telamona querci Fitch.

Telamona querci Fitch, Homop. N. Y. St. Cab., p. 51, 1851.
Telamona quercus Walker, List Homop., iv, p. 1145, 1852.
Thelia quercus Smith, Cat. Ins. N. J., edn. 1, p. 441, 1891.
Telamona brunneipennis Buckton, Monog. Membr., p. 197, pl. 48, fig. 1, 1903.

Funkhouser gives the following technical description:

Very close to *T. monticola;* pronotum shorter, darker; dorsal crest with prominent pale fascia on posterior margin; tegmina nearly hyaline, tips faintly clouded.

Head roughly sculptured, flavous mottled with brown, faintly longitudinally striate, very faintly punctate, pubescent, base weakly sinuate; eyes prominent, dark brown; ocelli very prominent, protruding, brownish, margins pale, much nearer to each other than to the eyes; clypeus nearly flat, punctate, pubescent, base marked with brown, tip extended below inferior margin of face.

Pronotum densely but finely punctate, sparingly pubescent, dark brown mottled with green; metopidium convex, median carina prominent, black interrupted with pale green; humeral angles short and blunt; dorsal crest sloping backward, longer than high, higher before than behind, posterior margin distinctly pale; posterior process short, acute, marked with greenish before apex, not reaching tips of tegmina.

Tegmina hyaline, bases punctured but not pubescent, tips clouded with brown, veins brown. Undersurface of body brown. Legs flavous; tibiæ hairy.

Length of pronotum, 9 mm.; to tips of tegmina, 11 mm.; width, 5.5 mm.

Distribution. Van Duzee reports this species from Ontario, New York, District of Columbia, Ohio, Colorado, New Mexico, and Nevada. Popenoe reports this species from Kansas, and there is a specimen in the Snow collection from Kansas City, Mo., so that it doubtless occurs in the state. The writer took a single specimen of the species at St. Paul, Minn.

Hosts. Funkhouser gives white and chestnut oak as hosts.

Telamona unicolor Fitch.

Telamona unicolor Fitch, Homop. N. Y. St. Cab., p. 50, 1851.
Telamona fasciata Fitch, Homop. N. Y. St. Cab., p. 50, 1851.
Hemiptycha diffusa Walker, List Homop., Suppl., p. 143, 1858.

Funkhouser gives the following technical description:

Females large, brilliant uniform grass-green; males smaller, bright yellow with deep brown fascia. Very striking in color; large size; crest high and square; tegmina tipped with brown.

Female. Head nearly twice as wide as long, green punctate with brown, finely pubescent; eyes large, brown; ocelli large, orange, nearer to each other than to the eyes; clypeus deeply punctate, pubescent, tip in a pointed extension.

Pronotum concolorous green, fading to mottled yellow in cabinet specimens; very finely punctate and pubescent; metopidium more or less angular, median carina distinct, three small brown spots mesad of humeral angles; humeral angles produced, triangular, blunt; crest large, high, much higher before than behind, anterior margin less sloping than posterior, dorsal margin brownish; posterior process long, gradually acute, apex brownish and not reaching tips of tegmina.

Tegmina brownish hyaline, bases and costal regions punctate with black, tips clouded with dark brown, veins prominent. Undersurface of thorax flavous, abdomen yellowish, pubescent, ovipositor brown. Legs flavous; tibiæ mottled with brown; tarsi ferruginous.

Length, 11 mm.; width, 6 mm.

Male. Differs from female in size and color. Head mottled brown and yellow, much darker than that of female, much sculptured, inferior line of face strongly sinuate.

Pronotum bright yellow, metopidium strongly shaded with brown; dark brown fascia on front of dorsal crest; dark brown fascia on posterior third of crest extending gradually narrowed to lateral margin of pronotum; posterior median line of crest yellow, transverse band of yellow behind crest; apex of posterior process brown.

Undersurface of body deep brown. Legs strongly flavous marked with brown.

Length, 10 mm.; width, 5 mm.

Distribution. Van Duzee reports this species from Ontario, New York, New Jersey, Pennsylvania, North Carolina, Michigan, Illinois, Iowa, Kansas, Missouri and Texas. In Kansas it has been taken in Pottawatomie county.

Hosts. Funkhouser gives hickory, butternut, walnut and basswood as hosts.

Telamona extrema Ball.

Telamona extrema Ball, Proc. Biol. Soc. Wash., xvi, p. 179 pl. 1, fig. 1, 1903.

The original description follows:

Form of *unicolor* nearly, smaller, and with a still longer hump. Greenish testaceous. Length: female, 10 mm.; male, 9 mm. Width, 5 mm.

Pronotal hump very high, almost quadrate, occupying the anterior three-fifths of pronotum, anterior margin rising perpendicularly from face, crest highest just back of the well rounded anterior angle from which it slopes slightly to the almost perpendicular posterior face. Humeral angles moderate, as long as the eyes.

Color: Greenish testaceous; a spot above each eye and the median carina back to the posterior angle of hump fuscous; posterior face of hump broadly marked with creamy white, which narrows to a line on the carina posteriorly in the female, and disappears entirely in the male. The lower margin of the humeral angles is sometimes marked with fuscous.

Distribution. This species was described from specimens taken in Iowa, and Marion county, Kansas. Van Duzee reports it also from Massachusetts, Rhode Island and New Jersey.

Hosts. Ball gives oak as a host.

Telamona collina (Walker).

Thelia collina Walker, List Homop., ii, p. 565, 1851
Telamona collina Butler, Cist. Ent., ii, p. 220, 1877
Telamona turritella Buckton, Monog. Membr., p. 198, pl. 44, fig. 6, 1903

The following is the original description:

Testacea vel viridi-flava; prothorax apice niger; carina ferruginea vel fulva; alæ limpidæ; alæ anticæ basi fulvæ.

Testaceous, shining: head finely punctured, short, almost transversely spindle-shaped, much narrower than the fore-chest, impressed on each side of the disk, with five slight undulations along the hind border, and seven on the fore border; a slight furrow extends from the hind border to the face, whose hind side is slightly obconical and occupies less than half the length of the face: fore-chest roughly punctured, convex and with a slight middle ridge in front, forming on each shoulder a conical, flat, very prominent horn; keel very deep behind the shoulders, conical and slightly inclined forward, veined along the lower side, slightly undulating and declining abruptly along half its length, straight and slightly attenuated from thence to the tip, which is black and extends far beyond the tip of the abdomen; ridge mostly ferruginous; sides slightly tumid; wings colorless; veins tawny; fore-wings partly brown along the hind borders and at the tips, tawny and punctured towards the base. Length of the body, 4 lines; of the wings, 10 lines.

New York.

Var. β. Head and fore part of the fore-chest pale yellow tinged with green; keel tawny, partly green; legs tinged with green; oviduct pitchy, curved.

St. John's Bluff, E. Florida.

Distribution. Van Duzee reports this species from New York, Pennsylvania and Florida. It has also been taken in Johnson county, Kansas.

Hosts. Mrs. Slosson and Van Duzee report it from sycamore.

Telamona tristis Fitch.

Telamona tristis Fitch, Homop. N. Y. St. Cab., p. 51, 1851.
Telamona coryli Fitch, Homop. N. Y. St. Cab., p. 51, 1851.
Telamona spreta Goding, Bul. Ill. St. Lab. Nat. Hist., iii, p. 417, 1894

Funkhouser gives the following technical description:

Near *T. ampelopsidis* in appearance, but smaller and lighter and differing in coloration; crest high and square, higher before than behind; tegmina hyaline tipped with brown; pronotum yellow mottled with red-brown.

Head subquadrate, yellowish, faintly longitudinally striate, finely punctate, closely pubescent, faintly mottled with brown; eyes prominent, brown; ocelli pearly, nearer to each other than to the eyes; clypeus pubescent, tip slightly extending below inferior margin of face.

Pronotum densely punctate, not pubescent, ground color light yellow, a broad transverse reddish-brown fascia nearly covering metopidium, a second on front of crest, and a third extending down posterior third of crest and reaching lateral margin of pronotum; humeral angles produced, triangular, flattened, blunt, tips dark; dorsal crest nearly square, truncate at tip, posterior margin pale; posterior process long, sharp, not quite reaching tips of tegmina.

Tegmina smoky hyaline, bases opaque and punctate, tips brown. Undersurface of thorax flavous; abdomen brown. Legs ferruginous.

Length, 8.5 mm.; width, 5 mm.

Distribution. Reported from Ontario, New York, New Jersey, Pennsylvania and Illinois. There are specimens in the Snow collection from Kansas City, Mo., so it doubtless occurs in Kansas.

Hosts. Funkhouser reports this species from hazelnut and oak.

Telamona ampelopsidis (Harris).

Membracis cissi (Harris MS), List Ins. Mass., in Hitchcock, Geol. Mass., p. 584, 1833.
Membracis ampelopsidis Harris, Rept. Ins. Mass., p. 181, 1841
Thelia cyrtops Fairmaire, Ann. Soc. Ent. Fr., ser. 2, iv, p. 310, 1846.
Telamona ampelopsidis Fitch, Homop. N. Y. St. Cab., p. 51, 1851
Telamona monticola Uhler, Stand. Nat. Hist., ii, p. 225, fig. 302, 1884.

Funkhouser gives the following technical description:

Fine, large, well-marked species; crest high, erect, front margin nearly perpendicular, hind margin sloping; ground color grayish with brown transverse fascia across metopidium, deep brown area at frontal base, brown fascia extending from posterior tip of crest to lateral margin of pronotum; tegmina hyaline, with brown tips.

Head yellowish, faintly marked with brown below, sculptured, finely punctate, sparingly pubescent; eyes prominent, grayish brown; ocelli large, yellowish, nearer to each other than to the eyes; clypeus smooth, pubescent, tip triangular.

Pronotum finely punctate, very sparingly pubescent; metopidium yellow at frontal margin, black spot above each eye, median carina prominent, black; humeral angles prominent, blunt, extending beyond the eyes as far as the length of the eyes; dorsal crest higher before than behind, margin somewhat flattened; posterior process long, strong, heavy, extending almost to tips of tegmina.

Tegmina hyaline, lightly punctate at base and along costal margins, tips brown. Undersurface of body generally uniform gray-brown.

Male smaller and darker than female, often without characteristic markings.

Length: female, 10 mm.; male, 8-9 mm. Width: female, 6 mm.; male, 5 mm.

Distribution. This species has been reported from Massachusetts, New York, New Jersey, Maryland, North Carolina, Illinois, Kansas and Colorado. It has been taken in Kansas in Riley, Leavenworth and Douglas counties.

Hosts. Occurs only on *Psedera quinquefolia*, our common Virigina creeper.

GENUS TELAMONANTHE Baker.

The members of this genus greatly resemble those of the preceding genus in general appearance, but they are smaller insects as a rule and are all characterized by having the basal costal cell of the tegmina completely punctate.

One species of the genus has been taken in Kansas and another at Kansas City, Mo., so that both doubtless occur in the state.

These species may be separated by the following key:

KEY TO SPECIES.

A	Crest nearly quadrate, humeral angles very long.	*rileyi*.
AA.	Crest rounded, humeral angles short.	*modesta*.

Telamonanthe rileyi (Goding).

Telamona rileyi Goding, Ent. News, III, p. 108, 1892.
Telamona coquilletti Goding, Bul. Ill. St. Lab. Nat. Hist., III, p. 420, 1894.
Telamonanthe rileyi Baker, Can. Ent., XXXIX, p. 115, 1907.

The original description follows:

Similar in size and form to *coquilletti* Goding; the markings are less prominent, lateral horns much less produced.

Male. Greenish yellow, marked with ferruginous lines, punctured. Head greenish yellow, lightly punctured. Prothorax yellowish green, mottled with ferruginous, longitudinal, elevated lines; dorsal carina percurrent, a deeply impressed dot on each side of its base; dorsal crest somewhat elevated, much compressed, strongly compressed anteriorly at base and posteriorly behind middle, the highest point of crest at beginning of postesior third, from which point it gradually slopes anteriorly in a gentle curve continuous with anterior third of prothorax, posteriorly sloping for a short distance, then forming an obtuse angle; at the base another obtuse angle is formed, from which the median carina curves gently to the apex; lateral angles a little prominent; tegmina with basal half coriaceous, apical half subcoriaceous, a brown spot at apex. Chest below is dark yellow, coxæ piceous. Legs yellow and hairy; abdomen yellow. Length, 6 mm.

Habitat: Marlo county, Cal.

Distribution. The type specimen came from California. There are specimens in the Snow collection from Arizona and from Lincoln county, Kansas.

Hosts. Unknown.

Telamonanthe modesta (Goding).

Telamona modesta Goding, Bul. Ill. St. Lab. Nat. Hist, iii, p. 420, 1894.

The original description follows:

Head triangular, hairy; ocelli nearer to each other than to the eyes. Prothorax broad, convex in front, gradually elevated back of lateral angles in a very high, much compressed, crest, the upper and anterior edges continuously curved to base of prothorax; posterior superior angle rectangular, posterior edge straight, inclined forward somewhat; posterior process long, depressed, acuminate, gradually attenuated to apex; sordid greenish yellow covered with black punctures, hairy, two black impressed dots over each eye, one above the other; base of posterior process and posterior edge of crest more or less free from black punctures. Tegmina with basal half of corium punctured, subtransparent. Legs triquetrous, tibiæ punctured with black, covered with spines. Abdomen and chest greenish-yellow.

Length, 8 mm.; breadth 4 mm.; altitude, 5 mm.

Habitat: Galesburg, Ill.

Distribution. Types from Illinois. There is a specimen in the Snow collection from Kansas City, Mo., so the species undoubtedly occurs in Kansas.

Hosts. Unknown.

GENUS ARCHASIA Stal.

The members of this genus are at once recognized by the broad, leaflike and compressed expansion of the pronotum.

Van Duzee separates the two species occurring in Kansas by the following key:

KEY TO SPECIES.

A. Dorsal edge distinctly brown or fuscous, the contour obviously concave before the apex. *belfragei.*

AA. Dorsal edge concolorous or faintly dotted with brown, contour scarcely if at all concave before the apex. *galeata.*

Archasia belfragei Stal.

Archasia belfragei Stal, Of. Vet. Akad. Forh., xxvi, p. 250, 1869.
Archasia canadensis Provancher, Pet. Faune Ent. Can., iii, p. 230, 1889.

Funkhouser gives the following technical description:

Green, fading to yellowish in cabinet specimens; pronotum high, strongly foliaceous, dorsal margin brown; tegmina about half concealed by pronotum; posterior process not reaching apices of tegmina.

Head nearly twice as wide as long, smooth, sparingly pubescent; base high and sinuate; eyes very prominent, shining dark brown; ocelli pearly, prominent, nearer to each other than to the eyes.

Pronotum closely but weakly punctate, not pubescent; humeral angles small, triangular; dorsal crest very high, flattened, foliaceous, almost vertical above head, slightly concave above head, posterior margin gradually hollowed out before apex of posterior process, entire dorsal margin flattened and uniformly brown.

Tegmina smoky hyaline, bases and costal margins punctate, tips strongly marked with brown. Undersurface of body yellow-brown; abdomen brown Legs dull yellow-brown; tibiæ pubescent.

Length, 9 mm.; width, 4.5 mm.; height of pronotum, 5 mm.

Distribution. Van Duzee reports this species from Ontario, Massachusetts, New York, New Jersey, North Carolina, Illinois and Michigan. There is a specimen in the Snow collection from Kansas City, Mo., so it undoubtedly occurs in Kansas also.

Hosts. Funkhouser gives locust and oak as hosts.

Archasia galeata (Fabricius.)

Membracis galeata Fabricius, Syst. Rhyng., p. 9, 1803.
Thelia galeata Fairmaire, Ann. Soc. Ent. Fr., ser. 2, iv, p 309, 1846
Smilia auriculata Emmons, Nat Hist. N. Y Ins., p. 153, pl. 3, fig. 12, 1854

The following describes this species:

Green, fading to yellowish in cabinet specimens; pronotum very high and strongly foliaceous, dorsal margin concolorous or spotted with brown; tegmina about half concealed by pronotum; posterior process not reaching apices of tegmina.

Head slightly longer than in preceding species, smooth, sparingly pubescent; base high and sinuate; eyes very prominent, shining dark brown; ocelli pearly, prominent, nearer to each other than to the eyes.

Pronotum closely but distinctly punctate, sparsely pubescent; humeral angles smaller and more rounded than in preceding species and the dorsal crest higher, not concave above the head, with posterior margin not at all concave before apex of posterior process, the entire dorsal margin strongly flattened.

Tegmina smoky hyaline, bases and costal margins punctate, tips slightly darker. Entire undersurface and legs yellowish-brown, the tibiæ pubescent.

Length, 9-11 mm.; width, 4.5-5 mm.; height of pronotum, 6 mm.

Distribution. Van Duzee reports this species from Ontario, New York, New Jersey, Pennsylvania, North Carolina, Georgia, Florida, Illinois, Iowa, Colorado, Utah and Texas. Specimens are at hand from Douglas, Riley, Miami and Cowley counties, Kansas.

Hosts. Goding mentions *Eupatorium, Verbena hastata* and oak.

GENUS SMILIA Germar.

The members of this genus are of the same general shape as those of the preceding, because of the foliaceous dorsum, but the terminal cell of the hind wing is not sessile and truncate, but petiolate and triangular.

A single species occurs in Kansas.

Smilia camelus (Fabricius).

(Pl. VII, figs. 1, 2.)

Membracis camelus Fabricius, Syst. Rhyng., p. 10, 1803.
Smilia vittata Amyot & Serville, Hemip., p. 539, 1843.
Thelia camelus Walker, List Homop., ii, p. 562, 1851.
Thelia vittata Walker, List Homop., iv, p. 1143, 1852.
Smilia betulae Goding, Can. Ent., xxv, p. 196, 1893.
Antianthe compressa Buckton, Monog. Memb., p. 191, pl. 41, fig. 6, 1903.

Funkhouser gives the following technical description:

Pronotum high and foliaceous, extending forward over the head; brown with broad diagonal stripe of green or yellowish followed by a parallel translucent band and a white spot; males much smaller and darker than females.

Head triangular, sculptured, yellow with scattered brown punctures and hairs; eyes brown; ocelli pearly, margins raised, nearer to each other than to the eyes; clypeus continuing inferior line of face, apex slightly produced.

Pronotum coarsely punctured, punctures farther apart in pale parts; wide green band extending from anterior dorsal angle of crest to lateral margin of pronotum, this band fading to yellowish in dried insects; wide translucent band from behind middle of dorsum to lateral base of crest; white spot at posterior base of crest; humeral angles hardly produced, short, rounded; posterior process short, pointed, not reaching tips of tegmina.

Tegmina hyaline, bases punctate with brown, apices brown. Undersurface of body brownish yellow. Legs flavous.

Length: female, 9 mm.; male, 7-8 mm. Width: female, 3 mm.; male, 2.5-3 mm.

Internal male genitalia. Styles with anterior portions broadened and flattened as in *Telamona*, the sparsely spined posterior portions of nearly same width to the laterally curved and doubly toothed apices; connective large, broad, much as in *Telamona;* œdagus, viewed laterally, large, U-shaped, anterior arm lightly chitinized and longer than the more heavily chitinized posterior arm, with a distinct knob at base and also about midway up the anterior arm, the posterior arm with functional orifice on caudal aspect of apex and covered with teeth on the cephalic aspect.

Distribution. Van Duzee reports this species from Ontario, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, North Carolina, Georgia, Florida, Illinois, Michigan, Iowa, Missouri, and Texas. Specimens have been taken in Kansas in Douglas and Montgomery counties.

Hosts. Funkhouser gives locust and oak as hosts.

GENUS CYRTOLOBUS Goding.

The members of this genus are usually brownish insects without prominent humeral angles, with a compressed dorsum, and frequently with a thin, semitransparent spot below the dorsal ridge.

The genus is represented by at least nine species in Kansas, which live on various species of oaks.

Van Duzee divides the genus into four subgenera which he separates by the following key:

KEY TO SUBGENERA.

Pronotum strongly inflated posteriorly, the crest forming an inflated cyst before and behind the median pale spot. *Xantholobus.*

Pronotum not strongly inflated, the crest however, usually more or less distinctly compressed on the median spot 1

1. Dorsal crest low and sinuated at the middle; form elongated and much depressed *Evashmeadea.*
   Dorsal crest not distinctly sinuated above 2
2. Crest highest anteriorly over or before the humeral angles, the dorsum sloping and nearly rectilinear to the apex. *Atymna.*
   Crest regularly arcuated above in the more typical examples, or in any case with the highest point at or near the middle. *Cyrtolobus.*

Subgenus CYRTOLOBUS Goding.

KEY TO SPECIES.

A. Dorsum without anterior notch or depression.
  - B. Crest well developed. *celsus*
  - BB. Crest distinctly lower. *fenestratus.*

AA. Dorsum with anterior depression before elevation.
  - B. Crest arising before humeral angles. *fuliginosus.*
  - BB. Crest arising behind humeral angles.
    - C. Large species, at least 9 mm. in length. *tuberosus*
    - CC Small species, not over 7 mm. in length.
      - D. Crest low or obsolete.
        - E. Species distinctly brownish. *griseus.*
        - EE. Species distinctly greenish. *cinereus.*
      - DD. Crest well developed; pronotum with distinct oblique bands. *vau.*

Cyrtolobus celsus Van Duzee.

Cyrtolobus celsus Van Duzee, Check List Hemip., p 60, 1916 (n. n. for *fenestratus* Van D.).

Cyrtolobus fenestratus Van Duzee, Bul. Buf. Soc Nat. Sci., ix, p 81, 1908

The following is the original description:

Pronotum well elevated, highest at about the middle, almost regularly arcuated from base to tip, the dorsal line a very little broken at the posterior vitta. Head and the pronotum anterior to the oblique line pale yellowish testaceous, punctured and varied with brown; from above each eye a brown indefinite vitta curves backward over the humeral angle; anterior oblique vitta almost perpendicular at first, approaching the elongated median mark, then deflected and again widened at apex so as to pass almost straight across the dorsal carina; posterior vitta transverse, represented in my Atlanta specimen only by a narrow spot on the carina; the surface behind the anterior vitta darker, in one example almost piceous. Elytra hyaline, the smoky apex small and pale.

Face coarsely punctured; clypeus broad, moderately produced, and strongly incurved.

Length, 6 mm.; height, 3 mm.

Distribution. Van Duzee reports this species from Massachusetts, New York, New Jersey and Georgia. It has also been taken near Kansas City, Mo., and therefore undoubtedly occurs in Kansas.

Cyrtolobus fenestratus (Fitch).

Cyrtosia fenestrata Fitch, Homop. N. Y. St Cab, p. 49, 1851.
Cyrotolobus fenestratus Goding, Can. Ent., xxv, p. 172, 1893.
Cyrtolobus muticus Van Duzee, Bul Buf. Soc. Nat. Sci., ix, p 83, 1908 (in part).

The following is the original description:

Yellow marbled with rufous; a pellucid spot behind the summit of the keel and a smaller one halfway to the apex; an oblique yellow vitta below the anterior spot, margins with fuscous or sanguineous; tip of the thorax reaching beyond the terminal cells of the elytra. Male black, the pellucid spots almost obsolete and the yellow vitta replaced by a few yellow dots.

Length, 0.25. On oaks.

Distribution. Van Duzee reports this species from Massachusetts, New York, New Jersey, Pennsylvania, North Carolina, Georgia, Florida, Mississippi, Ohio, Illinois, Colorado, Dakota. Specimens have been taken at Kansas City, Mo., so it surely occurs in Kansas.

Cyrtolobus fuliginosus (Emmons).

Cyrtosia fuliginosa Emmons, Nat Hist. N. Y. Ins., p. 154, pl. 13, fig. 15, 1854
Cyrtolobus fuliginosus Goding, Can. Ent., xxv, p 172, 1893.

Funkhouser gives the following technical description:

Near *C. ovatus* in appearance, but smaller, darker, and with lower crest; dark sordid brown with faint transverse bands; head projecting slightly forward; posterior process just reaching tips of tegmina; tegmina strongly marked with brown, apices lighter.

Head somewhat extended forward, yellow, mottled with deep brown, deeply punctate with brown, not pubescent, a black spot at base of head above each ocellus; eyes large, brown, lighter in color than remainder of head; ocelli small, pearly, about equidistant from each other and from the eyes; clypeus convex, sculptured, a brown line on each side, tip continuing rounded inferior outline of face.

Pronotum dark brown, transverse fascia extending from anterior base of crest to lateral margin of pronotum, this fascia light brown before and very dark brown behind; entire pronotum deeply and densely punctate; humeral angles weak, angular but blunt; dorsal crest regularly arcuate from above humeral angles to base of posterior process; posterior process heavy, short, blunt, just reaching apices of tegmina.

Tegmina smoky brown, apical cells lighter, apical margins fuscous, bases and costal margins roughly punctate. Legs and undersurface of body flavous.

Length, 6 mm.; width, 2.5 mm.

Distribution. Hitherto reported only from New York. Specimens have been taken, however, at Kansas City, Mo., and so it may safely be included in the Kansas fauna.

Hosts. Funkhouser reports it from white oak.

Cyrtolobus tuberosus (Fairmaire).

Thelia tuberosus Fairmaire, Ann. Soc Ent. Fr., ser. 2, iv, p. 307, 1846.
Cyrtolobus tuberosus Goding, Bul. Ill. St. Lab. Nat. Hist., iii, p. 433, 1894.

Funkhouser gives the following technical description:

Largest species of the genus; brown mottled with darker brown; dorsal compression strikingly transparent; dorsal crest situated well back on pronotum, posterior process very short; tegmina smoky hyaline tipped with brown.

Head triangular, broader than long, ochraceous tinged with red and punctate with brown, not pubescent; base weakly sinuate; inferior margin of face strongly sinuate; eyes large, brown; ocelli small, yellowish, slightly protruding, nearer to each other than to the eyes; clypeus convex, brown line on each side, tip extended and hairy.

Pronotum deeply and closely punctate, light greenish brown; crest dark brown with pale compression at anterior base, in the middle, and at posterior base; middle compression very large and transparent, posterior half of crest dark brown with color extending in a dark band to margin of pronotum; metopidium very convex, median carina prominent; humeral angles prominent, rounded; posterior process short, sharp, brown, inferior lateral margin slightly sinuate, not reaching tips of tegmina.

Tegmina brownish hyaline, tips strongly marked with brown, bases punctate. Undersurface of thorax yellow. Legs ferruginous, hind trochanters marked with brown; tarsi flavous; claws brown.

Length, 9.5 mm.; width, 4 mm. Male smaller than female, but similarly colored.

Distribution. Reported by Van Duzee from Massachusetts, New York, North Carolina, Georgia, Florida, Mississippi and Illinois. There is a specimen in the Snow collection from Kansas City, Mo., so it is sure to occur in Kansas.

Hosts. Funkhouser reports it from red oak and hickory.

Cyrtolobus griseus Van Duzee.

Cyrtolobus griseus Van Duzee, Bul. Buf. Soc. Nat. Sci., ix, p. 90, 1908.

The following is the original description:

This form, which is very near *cinereus*, is of an almost uniform dark cinerous, closely punctured with fuscous. The only conspicuous marking is the oblique blackish vitta which in *cinereus* bounds the hind margin of the anterior oblique vitta. Before and behind this brown band or line the surface is a little lighter and there is a suggestion of the median dorsal spot and transverse posterior vitta. In some specimens there is an arcuated longitudinal brown vitta on either side of the metopidium. Here the elytra are hyaline with the costal base ferruginous grey and punctured, and the apex has a small fuscous cloud.

The tergum is black with a broad white band at the base as in the allied species, which, showing through the closed elytra, indicates the markings found on the elytra of *cinereus*. Face obviously longer and more convex than in *cinereus*, with the basal middle depressed, and the clypeus and loræ together larger, the former much broader, more convex and more decurved and rounded at apex.

Distribution. The type material was taken at Effingham, Kansas.

Cyrtolobus cinereus (Emmons).

Gargara cinereus Emmons, Nat. Hist. N. Y. Ins., p. 156, pl. 13, fig. 3, 1854.
Cyrtosia ornata Provancher, Pet. Faune Ent Can., iii, p. 240, 1889.
Cyrtosia cinerea Harrington, Ottawa Nat., vi, p. 30, 1892.
Cyrtolobus cinereum Goding, Can Ent., xxv, p. 172, 1893
Atymna cinereum Goding, Bul. Ill. St. Lab Nat. Hist., iii, p. 436, 1894.
Cyrtolobus cinereus Van Duzee, Bul. Buf. Soc. Nat. Sci., ix, p. 91, 1908.

Funkhouser gives the following technical description:

Small greenish gray mottled with brown and banded with green; pronotum low and regularly arcuate; metopidium convex; posterior process short but sharp; tegmina wrinkled, hyaline, apices brown.

Head convex, pale grayish green, sharply punctate with black, sparingly pubescent; base nearly straight; eyes prominent, brown; ocelli large, reddish, prominent, slightly farther from each other than from the eyes and situated slightly below an imaginary line extending through centers of eyes; clypeus flat, somewhat trilobed, a faint brown line on each side, extending below inferior margin of face.

Pronotum green-gray tinged with reddish, closely punctate, not pubescent; dorsal crest very low, median spot on margin pale; a transverse pale band bordered with brown extending from anterior base of crest backward and downward to lateral margin of pronotum, a similar band extending from base of posterior process downward and forward to almost meet the anterior stripe and form a V with it; posterior process short, not reaching tips of tegmina.

Tegmina wrinkled, hyaline, brown spot at base of each, another in middle, and a third at tip; areas between hyaline. Legs and undersurface of body grayish flavous.

Length, 5.8 mm.; width 2.5 mm.

Distribution. Reported by Van Duzee from Quebec, New York and New Jersey. A single specimen of this species was taken in Douglas county, Kansas, and is in the Snow collection. Specimens have also been taken in Riley county.

Cyrtolobus vau (Say).

(Pl. VII, figs. 5, 6.)

Membracis vau Say, Jl. Acad. Nat. Sci. Phila., vi, p. 299, 1831.
Thelia semifascia Walker, List Homop., ii, p. 561, 1851.
Smilia vau Fitch, Homop. N. Y. St. Cab., p. 48, 1851.
Thelia vau Walker, List Homop., iv, p. 1142, 1852.
Cyrtosia vau Provancher, Pet. Faune. Ent. Can., iii, p. 238, 1889.
Cyrtosia fenestrata Provancher, Pet. Faune Ent. Can., iii, p. 239, 1889.
Cyrtolobus nigra Goding, Can. Ent., xxv, p. 172, 1893.
Cyrtolobus punctifrontis Goding, Can. Ent., xxv, p. 172, 1893

Cyrtolobus tricincta Goding, Can. Ent., xxv, p. 172, 1893.
Cyrtolobus vau Goding, Can. Ent., xxv, p. 172, 1893.
Thelia fasciata Buckton, Monog. Membr., p. 189, 1893.
Argante semifasciata Buckton, Monog. Membr., p. 189, pl. 40, fig. 9, pl. 41, fig. 1, 1903.
Cyrtolobus varius Smith, Cat Ins. N. J., edn. 3, p. 92, 1910.

Funkhouser gives the following technical description:

Small robust species, with low pronotum and prominent markings; varies greatly in color and somewhat in size; females larger and lighter than males, but with constant markings; transverse pronotal band prominent, pale bordered with deep brown; dorsal compression deep and translucent; posterior process short, blunt, not reaching tips of tegmina; tegmina hyaline, with bases and tips slightly brown.

Head small, subtriangular, pale yellow punctured with brown; base feebly sinuate; inferior margin of face sinuate, clypeus extending slightly below line; eyes large, gray-brown; ocelli small, yellowish, somewhat nearer to each other than to the eyes; clypeus hairy.

Pronotum closely and roughly punctate; median compressed spot round, transparent; dorsal crest low, arising above humeral angles and gradually extending with only a faint sinus before posterior process; posterior process short, blunt, tectiform, reaching to bases of apical cells of tegmina.

Tegmina hyaline, veins prominent, bases and apices smoky hyaline. Legs and undersurface of body uniform flavous.

Length, 5.5-6.5 mm.; width, 2.4-2.6 mm.

Internal male genitalia. Styles rather long and slender, curved strongly laterad apically, and bearing several spiny tubercles on the lateral margins just cephalad of the terminal tooth; connective triangular; œdagus, viewed laterally, large, U-shaped, anterior arm slightly chitinized and with a large prominence about half way on its cephalic aspect, posterior arm heavily chitinized, apex with file-like teeth on the side opposite the functional orifice.

Distribution. Reported by Van Duzee from Ontario, Maine, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, District of Columbia, North Carolina, Georgia, Florida, Illinois, Kansas, Missouri, Arkansas, Texas, New Mexico and Colorado. There are specimens in the Snow collection from Douglas, Riley, and Pottawatomie counties, Kansas.

Hosts. Funkhouser gives white, chestnut, red and scarlet oak as hosts.

Subgenus ATYMNA Stal.

In this subgenus the pronotum is highest at the anterior end. It is represented in Kansas by a single species.

Cyrtolobus querci (Fitch).

(Pl. VII, figs. 3, 4.)

Smilia querci Fitch, Homop. N. Y. St. Cab., p. 49, 1851.
Thelia querci Walker, List Homop., iv, p. 1143, 1852.
Gargara querci Emmons, Nat. Hist. N. Y. Ins., p. 156, pl. 13, fig. 8, 1854.

Atymna querci Van Duzee, Psyche, v, p. 390, 1890.
Cyrtolobus (Atymna) querci Van Duzee, Bul. Buf. Soc. Nat. Sci., v, p. 188, 1894.

Funkhouser gives the following technical description:

Females large and green, males smaller and brown with a broken yellow median dorsal stripe; body long and narrow; crest highest above humeral angles and gradually sloping to posterior apex without a sinus.

Female. Head projecting slightly forward, pale yellow, sculptured, irregularly punctate, not pubescent; eyes very prominent, reddish; ocelli not prominent, yellow; clypeus extending below inferior margin of face.

Pronotum uniform green, roughly punctate, not pubescent, dorsal line faintly marked with brown; posterior process short, acute, not reaching tips of tegmina.

Tegmina entirely hyaline, bases and costal margins faintly punctate; hind wings iridescent. Legs and undersurface of body green.

Length, 7 mm.; width, 2.5 mm.

Male. Head sordid yellow, sculptured, sparingly punctate; eyes prominent, brown; ocelli pearly; clypeus marked with brown at base.

Pronotum chocolate brown with bright yellow stripe on median dorsal line and yellow band before apex.

Tegmina smoky hyaline with brown cloud at apices. Undersurface of thorax brownish; abdomen very dark brown, nearly black. Legs flavous; tarsi ferruginous; claws fuscous.

Length, 6 mm.; width, 2 mm.

Internal male genitalia. Styles small, anterior portion quite short, posterior portions larger, bearing spiny protuberances apically; connective rather large, triangular; œdagus, viewed laterally, very large compared with the styles, anterior arm long and slender, posterior arm stout and with many filelike teeth on the side opposite the functional orifice.

Distribution. Van Duzee reports this species from Ontario, Connecticut, New York, Pennsylvania, North Carolina, Georgia, Illinois, Michigan, Iowa and Missouri. Specimens having been taken at Kansas City, Mo., it is sure to occur in Kansas.

Subgenus XANTHOLOBUS Van Duzee.

In this subgenus the pronotum is distinctly inflated posteriorly. It is represented in Kanas by a single species.

Cyrtolobus muticus (Fabricius).

Membracis mutica Fabricius, Genera Ins., p. 297, 1776.
Cicada mutica Gmelin *in* Linnaeus, Syst. Nat., edn. 13, i, pt. 4, p. 2093, 1778.
Centrotus mutica Fabricius, Syst. Rhyng., p. 21, 1803.
Membracis trilineatus Say, Long's 2nd. Exped., p. 300, 1824; Compl. Writ., i, p. 200.
Cyrtosia mutica Stal, Hemip. Fabr., ii, p. 25, 1869.
Cyrtosia trilineata Provancher, Pet. Faune Ent. Can., iii, p. 239, 1889.
Cyrtolobus muticus Goding, Bul. Ill. St. Lab. Nat. Hist., iii, p. 431, 1894.

Funkhouser gives the following technical description:

Yellowish tinged with red; transverse band of pronotum often absent; pronotum long; head slightly projecting forward; eyes tinged with reddish; posterior process reaching tips of tegmina; tegmina entirely hyaline or faintly clouded with yellow.

Head slightly protruding forward, yellow with red punctures, sculptured, not pubescent; base irregularly sinuate; eyes gray marked with red; ocelli small, translucent, somewhat nearer to each other than to the eyes; clypeus swollen, convex, continuing inferior outline of face, tip slightly extended, hairy; antennæ prominent.

Pronotum yellowish with irregular reddish areas, deeply and roughly punctate, not pubescent; transverse band when present pale with reddish borders; humeral angles weak, blunt; dorsal crest elliptical, very slight sinus before base of posterior process, compressions not deep; posterior process heavy, blunt, just reaching tips of tegmina.

Tegmina hyaline or clouded with reddish yellow, tips pale, veins in some cases yellowish, bases and costal areas irregularly punctate. Legs and under-surface of thorax flavous; abdomen sordid yellow.

Length, 6 mm ; width, 2.8 mm.

Distribution. Reported by Van Duzee from Quebec, Rhode Island, New York, Pennsylvania and Illinois. In the Snow collection there are specimens from Kansas City, Mo., and some taken in Douglas county, Kansas. The writer took a specimen at St. Paul, Minn.

GENUS OPHIDERMA Fairmaire.

The members of this genus have a compressed and rounded dorsum which entirely lacks a crest.

It is represented in Kansas by three species, which may be separated by the following key:

KEY TO SPECIES.

A. Color, brown or mottled.
  B. Species smaller, mottlings more distinct. *salamandra.*
  BB. Species larger, mottling dull. *flaviguttula.*
AA. Color, green or yellowish green. *flava.*

Ophiderma salamandra Fairmaire.

(Pl. VI, figs 1, 2)

Ophiderma salamandra Fairmaire, Ann. Soc. Ent. Fr, ser. 2, iv, p. 493, 1846.

Funkhouser gives the following technical description:

Large brown species; dorsum rounded and very pubescent with short, black, bristly hairs; posterior process short, suddenly acute, not reaching apices of tegmina; tegmina hyaline, bases and costal areas strongly punctate, tips clouded with fuscous, veins very prominent; under part of body dark; males smaller and darker than females.

Head broader than long, yellow, feebly punctate, very hairy; base slightly, uniformly curved; eyes large, brown; ocelli prominent, red, nearer to each other than to the eyes; inferior margin of face sinuate; clypeus yellow with two vertical stripes of red; base hairy.

Pronotum coarsely punctate, densely pubescent, brown mottled with green; dorsum rounded, slightly depressed behind middle, lateral margin curved downward at middle; posterior process short, suddenly acute, not reaching tips of tegmina.

Tegmina smoky hyline, veins very prominent, nearly all of basal half below pronotum strongly punctate, tips clouded with fuscous; hind wings iridescent. Undersurface of head and thorax fuscous; abdomen flavous. Femora and tibiæ strongly marked with dark brown.

Length, 7.6 mm.; width, 3.2 mm.

Internal male genitalia. Styles rather short and broad, especially basally, posterior portion more slender, apices curved strongly laterad and ending in a small but distinct terminal hook on the lateral margin, in front of which is a distinct prominence which tapers gradually to the hook, the apical fourth of the styles bearing a few spines; connective almost pentagonal, with a pair of distinct knobs at the basal angles; œdagus, viewed laterally, U-shaped, anterior process with a large anterior prominence near the middle, posterior arm curved, the apex bearing the functional orifice caudally and many filelike and distinct teeth on its cephalic aspect.

Distribution. Reported by Van Duzee from Ontario, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, District of Columbia, Virginia, Georgia, Florida, Illinois and Michigan. There are specimens in the Snow collection also from Wisconsin, Arizona and Kansas City, Mo. It has also been taken in Pottawatomie county, Kansas.

Hosts. Oaks.

Ophiderma flaviguttula Goding.

Ophiderma flaviguttula Goding, Bul Ill St Lab Nat Hist, III, p 438, 1894.
Ophiderma flavoguttata Slosson, Ent. News, XVII, p 326, 1906.

The original description follows:

Female. Head triangular, yellowish; eyes prominent, dark brown; ocelli equidistant from each other and from the eyes, red; convex, densely pubescent. Prothorax with very slight median carina, densely pubescent, an irregular yellow patch starting at lateral border and extending upwards and forwards, midway between base and apex; an irregular band at base, concolorous with head, extending along sides in a greenish gray line; otherwise dirty brown, lightly punctured; apex of posterior process not reaching apex of tegmina. Tegmina subcoriaceous at base, lightly punctured, basal half and apex brown. Below yellow, feet and legs brown.

Length, 6.2 mm.

Distribution. Reported by Van Duzee from New Hampshire, Pennsylvania and Illinois. There are specimens in the Snow collection from Kansas City, Mo., so it undoubtedly occurs in Kansas.

Hosts. Probably oak.

Ophiderma flava Goding.

Ophiderma flava Goding, Insect Life, v, p 93, 1892 (nomen nudum)
Ophiderma flava Goding, Bul. Ill. St. Lab. Nat. Hist, iii, p. 439, 1894.

Funkhouser gives the following technical description:

Large greenish yellow species, fading to sordid yellow in cabinet specimens; body robust and long; posterior process not reaching apices of tegmina; tegmina hyaline, brown at base and fuscous-clouded at tips.

Head much broader than long, green, weakly and sparingly punctate, smooth, shining, sparingly pubescent; eyes large, red; ocelli prominent, reddish, about equidistant from each other and from the eyes; clypeus smooth, nearly black, base regularly rounded, tip extending below inferior margin of face.

Pronotum uniform green, in some cases tinged with reddish, closely and densely punctate, finely pubescent; dorsum rounded, depressed behind middle, median carina percurrent; posterior process heavy, tectiform, acute, not extending to tips of tegmina.

Tegmina hyaline, bases reddish and punctate, tips clouded with fuscous, veins heavy and inclined to be punctate along margin. Legs and undersurface of body entirely flavous.

Length, 7-8 mm.; width, 3-4 mm.

Distribution. Reported by Van Duzee from Quebec, Massachusetts, New York, Pennsylvania, North Carolina, Illinois, Michigan. There are specimens in the Snow collection from Columbia, Mo., and from Chautauqua county, Kansas.

Hosts. Unknown.

GENUS VANDUZEA Goding.

The members of this genus are distinguished by the transverse and basally truncate terminal cell of the elytra.

A single member of the genus is known to occur in Kansas.

Vanduzea triguttata (Burmeister).

(Pl. VI, figs. 7, 8.)

Entylia triguttata Burmeister, Silb. Rev. Ent., iv. p, 183, 1836
Vanduzea vestita Goding, Insect Life, v, p. 93, 1892.
Cyrtolobus annexus (Uhl. MS) Townsend, Can. Ent, xxiv, p. 196, 1892.

The following is Goding's description:

Head broad, black, perpendicular, triangular, a narrow dusky brown mark on upper edge just below origin of carina. Eyes prominent; ocelli equidistant from each other and the eyes. Front of prothorax blackish brown, fading posteriorly to a reddish brown in a triangular form, the apex of which reaches

three-fourths of the distance to apex of posterior process; lateral angles slightly produced; sides of prothorax from just behind lateral angles to apex black, interrupted by a light yellow, or whitish, trapezoidal spot on each side just behind middle of inferior border; just before the apex a white band across posterior part of process. Tegmina clear, with dark brown veins, or brown with a lighter band across middle. Legs and feet brown or black.

Length, 4.7 mm.

Internal male genitalia. Styles broad and flat basally, apical half slender, apices curved strongly dorsad and ending rather bluntly, bearing a few spines; connective nearly quadrangular, the base concave; œdagus, viewed laterally, U-shaped, anterior arm enlarged toward the base, posterior arm of nearly same width throughout, the apex bearing caudally the functional orifice and cephalad many filelike teeth.

Distribution. Reported by Van Duzee from District of Columbia, Florida, Colorado, New Mexico and Arizona. The writer has taken it at St. Paul, Minn. It has been taken in the following Kansas counties: Morton, Clark, Stevens, Logan, Haskell, Seward, Riley, Hamilton, Pottawatomie, Douglas and Miami.

Hosts. Common on black locust. Also taken by the writer on *Amorpha.*

GENUS ENTYLIA Germar.

The members of this genus are characterized by their high compressed dorsum, which bears a deep median notch.

A single species of the genus is known to occur in Kansas.

Entylia concisa Walker.

(Pl. VI, figs. 5, 6.)

Entylia concisa Walker, List Homop., II, p. 547, 1851.
Entylia decisa Walker, List Homop., II, p. 548, 1851.
Entylia concava Provancher, Pet. Faune Ent. Can., III, p. 233, 1889

The following is the original description:

Ferruginea; prothoracis carina altè bicristata, utrinque albo interruptè et obliquè fasciata; pedes flavi; alæ limpidæ; alæ anticæ basi et ad costam fulvæ.

Ferruginous; head and thorax roughly punctured; head transverse, almost semicircular, narrower than the fore-chest, slightly impressed with an indistinct middle suture which extends to the face, the hind border of the latter is angular and occupies nearly half the length of the head; shoulders very obtusely angular, not prominent: fore-chest forming two lofty compressed keel-shaped crests which incline towards each other and inclose three-fourths of a circle; the first rises between the shoulders and is truncated at the tip; the second is lower and above the keel; the latter is rather deep and extends far beyond the tip of the abdomen, whose sides it embraces; the irregular ridges on the sides of the crest communicate with the ridges of the keel, and the latter has an oblique white interrupted band on each side behind the second

crest; breast pitchy; abdomen black; a stripe on each side beneath and the tip yellow; legs yellow; wings colorless; fore-wings tawny at the base and along more than half the length of the fore border; veins pitchy, tawny where the wings are so, pale yellow near the tip of the fore border.

Length of the abdomen, 2½ lines; of the wings, 4½ lines.

Var. β. Breast and abdomen tawny; white bands of the keel hardly visible.

Var. γ. Breast and abdomen black; tip of the latter tawny.

St. John's Bluff, E. Florida.

Internal male genitalia. Styles small, anterior portion narrow, posterior part stouter, the apices curved strongly laterad and ending in a stout hook; connective large, triangular, apex abtuse, and longitudinally divided; œdagus, viewed laterally, U-shaped, anterior arm with a distinct protuberance, posterior arm stouter and ending in a large, serrated point.

Distribution. Van Duzee reports this species from District of Columbia, North Carolina, Georgia and Florida. It has been taken in Douglas, Pottawatomie and Wilson counties, Kansas.

Remarks. Funkhouser feels that *E. sinuata* is the very small southern form, *E. bactriana* the northeastern, and that *E. concisa* is our Kansas species. In the present confused status of the members of this genus it is perhaps best to accept his conclusions and to change our Kansas species to *E. concisa* instead of calling it *E. sinuata*, as did Miss Branch.

Hosts. Miss Branch reports this species from *Melilotus alba, Cnicus altissimus, Phleum alpinum, Helianthus annuus, Medicago sativa*, and *Ambrosia* sp. The writer has taken it very commonly in all its stages from *Ambrosia trifida, Xanthium* sp., and *Helianthus tuberosus*.

GENUS PUBLILIA Stal.

The members of this genus are closely related to those of the preceding genus, but have a much lower crest and a much weaker median notch.

All of the members of the genus found in the United States occur in Kansas. These may be separated by the following key given by Van Duzee.

KEY TO SPECIES.

A. Dorsum straight or feebly arcuated, scarcely if at all sinuated; form more slender. *modesta.*

AA. Dorsum more elevated, obviously sinuated.

- B. Sides of the pronotum with longitudinal rugæ which become more or less reticulated along the dorsum. *concava.*
- BB. Rugæ of the pronotum strong, irregularly reticulated over its whole surface. *reticulata.*

Publilia modesta Uhler.

(Pl. VI, fig. 3, 4.)

Publilia modesta Uhler, Bul. U. S. Geol. Geog Surv., I, p. 344, 1876
Publilia bicinctura Goding, Ent News, III, p. 200, 1892.

The original description follows:

General form of *P. concava* Say, but more decidedly vertical in front, and with the dorsal outline scarcely depressed before the middle; apex of the pronotum more slender and acute. Color pale yellow; the head and fore part of pronotum clouded with pale brown; a spot above the humeri, a broad oblique band behind the middle, and a broad cloud on the apex grayish brown; the dorsal edge irregularly spotted with dark brown, and the oblique band surmounted by a large brown spot The surface closely beset with series of coarse sunken punctures, the longitudinal and reticulated surface lines obsolete. Humeral margin of the sinus waved. Under side piceo-testaceous; the front, clypeus, pectus and venter, excepting the edges of the segments, black-piceous. Legs dull yellow, closely pubescent, clouded, and spotted with brown

Length, 4 to 4½ mm., breadth of pronotum, 2 mm.

Colorado (C. Thomas), also discovered in Utah, Dakota, Arizona, New Mexico, California.

In two specimens examined, the commonly raised lines on the surface of the pronotum were obliterated

Distribution. Besides the above localities specimens have been taken in Kansas in Gove and Trego counties.

Hosts. Gillette and Baker report this species on *Solidago*, alfalfa, *Helianthus*, *Iva*, and *Artemesia*. Goding gives *Glycyrrhiza lepidota* and mesquite as hosts.

Publilia concava (Say).

Membracis concava Say, Long's 2nd Exped., II, p. 301, 1824, Compl. Writ., I, p 200.
Entylia concava Germar, Silb Rev Ent, III, p. 249, 1835
Publilia concava Stal, Analecta Hem, p. 388, 1866
Ceresa concava Rathvon, in Mombert's Hist Lanc. Co, Pa., p. 551, 1869
Publilia grisea Buckton, Monog Membr., p 184, pl. 39, fig. 5, 1903
Publilia vittata Buckton, Monog Membr, p. 185, pl. 39, fig. 6, 1903

Funkhouser gives the following technical description:

Varies greatly in color and somewhat in shape, particularly in form of dorsal sinuation; color varies from gray to black; dorsum convex, tectiform, faintly ribbed, dorsal sinus shallow; pronotum irregularly ridged, deeply punctate; tegmina largely covered by pronotum, basal half of each costal area strongly punctate.

Head slightly projecting, strongly punctate with black; base nearly straight; inferior margin rounded; eyes not prominent; ocelli prominent, usually reddish; clypeus rounded, very wide at tip.

Pronotum deeply, densely and coarsely punctate, lateral areas marked with high, distinct, irregular, longitudinal ridges; dorsal margin sinuate just behind humeral angles, sinuation usually very shallow; posterior lobe gradually elliptical to posterior apex; posterior process heavy, high, tectiform, blunt, extending just beyond tips of tegmina.

Tegmina almost entirely concealed by pronotum; exposed costal margins opaque and punctate for basal half, apical areas hyaline, tips fuscous. Undersurface of body and femora usually very dark, generally black. Legs flavous.
Length, 5 mm.; width, 2.5 mm.

Internal male genitalia. Styles long and slender, the extreme anterior portion bent strongly laterad, widest opposite connective, the posterior part with distinct apical hook; connective widest at the concave base, the apex truncate; œdagus, viewed laterally, with strong anterior arm which bears two prominent rounded prominences, the posterior arm more slender, the apical portion bearing a few indefinite teeth on caudal margin and the apex characteristically retrorsely hooked.

Distribution. Van Duzee reports this species from Ontario, New York, New Jersey, North Carolina, Ohio, Illinois, Iowa, Missouri, Kansas, Arkansas, and Utah. It is also known to occur in Mexico. Specimens have been taken in Kansas in Douglas, Pottawatomie, Riley, and Gove counties

Hosts. Funkhouser gives golden rod and skunk cabbage as hosts. Goding mentions Canadian thistle. The writer has taken it in all stages on *Ambrosia trifida.*

Publilia reticulata Van Duzee.

Publilia reticulata Van Duzee, Bul Buf Soc Nat Sci, ix, p 106, 1908

The following is the original description:

Closely allied to *concava* but with the surface of the pronotum reticulated with strong anastomosing rugæ in place of the four or five simple longitudinal carinæ found in that species. These rugæ give the surface a strongly corrugated or areolated appearance Surface between the rugæ deeply punctured Metopidium more vertical than in *concava*, the percurrent carina more elevated and the dorsal sinus somewhat deeper. Apical margin of the head distinctly sinuated next the eye, then very obtusely arcuated about the apex. Color blackish or fuscous, speckled or blotched more or less with testaceous on the head and front of the pronotum as far as the dorsal sinus; and with a triangular whitish testaceous spot on the apical fourth of the lateral margin, which may be prolonged somewhat along the margin anteriorly and indistinctly across the disk as an incomplete subapical vitta. Venter, tibiæ and tarsi pallid, the disk of the ventral segments more or less black
Length, 4 mm.

Distribution. Van Duzee reports this species from New Jersey, Pennsylvania, North Carolina and Missouri. There is a specimen in the Snow collection from Kansas City, Mo., and it has been taken in Riley county.

Hosts. Unknown.

PLATE II.

1. Styles and connective of *Ceresa bubalus.*
2. Œdagus of *Ceresa bubalus.*
3. Lateral aspect of *Ceresa taurina.*
4. Genitalia of *Ceresa taurina.*
5. Styles and connective of *Ceresa bubalus.*
6. Œdagus of *Ceresa bubalus.*
7. Genitalia of *Ceresa bubalus.*
8. Lateral aspect of *Ceresa bubalus.*

PLATE II.

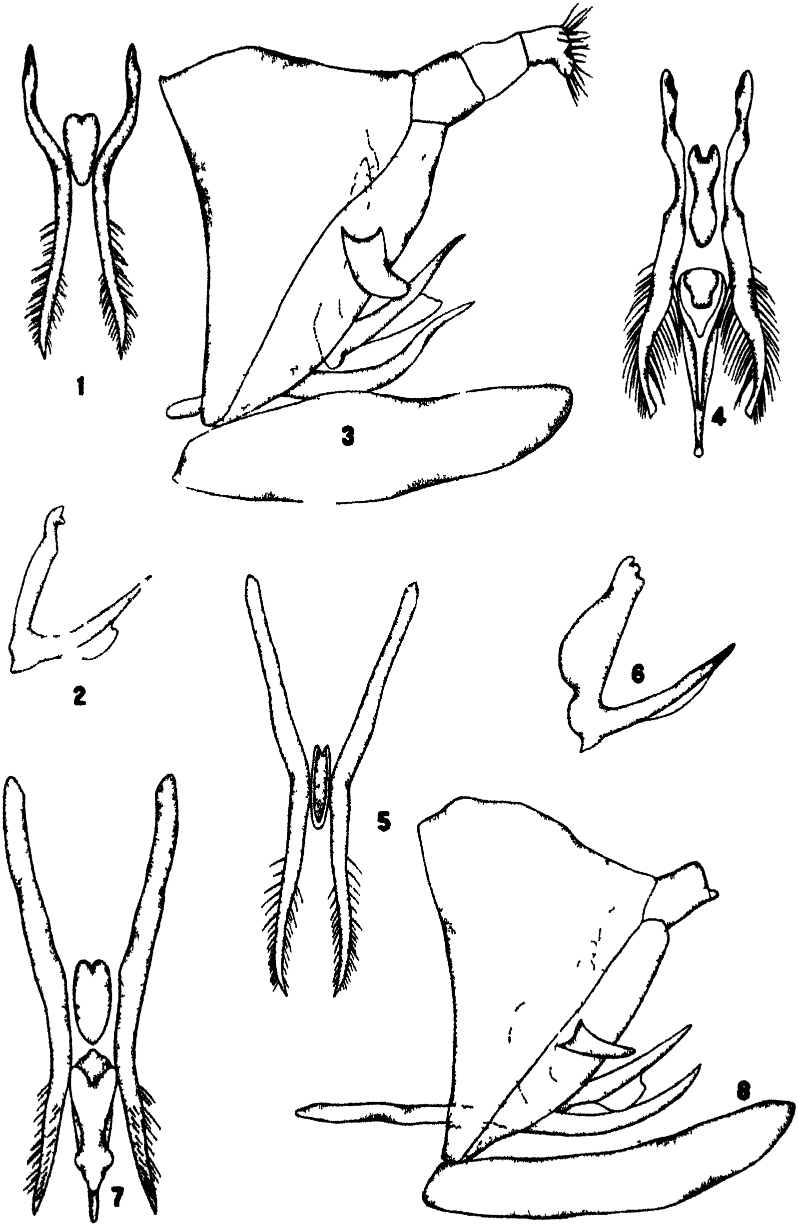


PLATE III.

1. Genitalia of *Ceresa diceros.*
2. Œdagus of *Ceresa diceros.*
3. Styles and connective of *Ceresa palmeri.*
4. Œdagus of *Ceresa palmeri.*
5. Styles and connective of *Stictocephala festina.*
6. Lateral aspect of *Stictocephala festina.*
7. Œdagus of *Ceresa borealis.*
8. Genitalia of *Ceresa borealis.*

PLATE III.

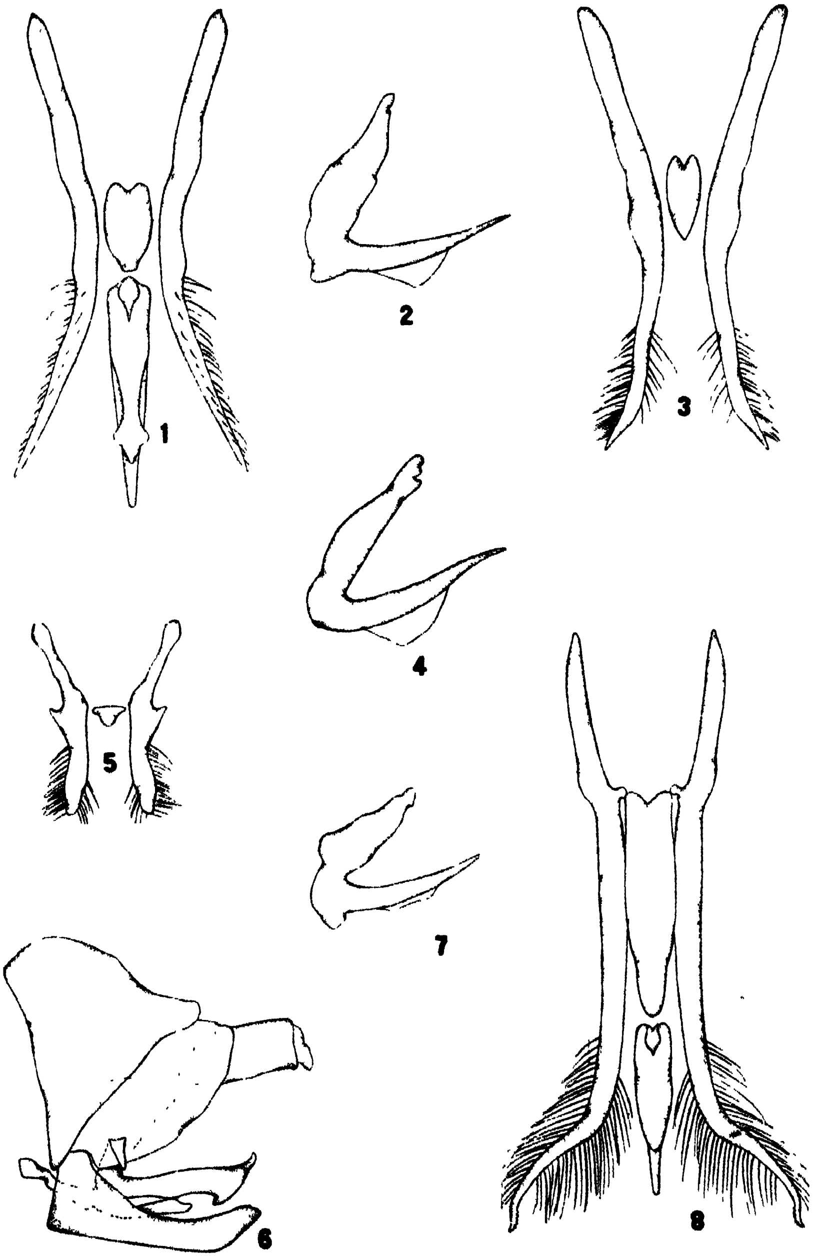


PLATE IV.

1. Genitalia of *Stictocephala inermis.*
2. Œdagus of *Stictocephala inermis.*
3. Genitalia of *Stictocephala lutea.*
4. Œdagus of *Stictocephala lutea.*
5. Genitalia of *Stictocephala inermis.*
6. Œdagus of *Stictocephala inermis.*
7. Lateral aspect of *Stictocephala inermis.*
8. Styles and connective of *Stictocephala inermis*

PLATE IV

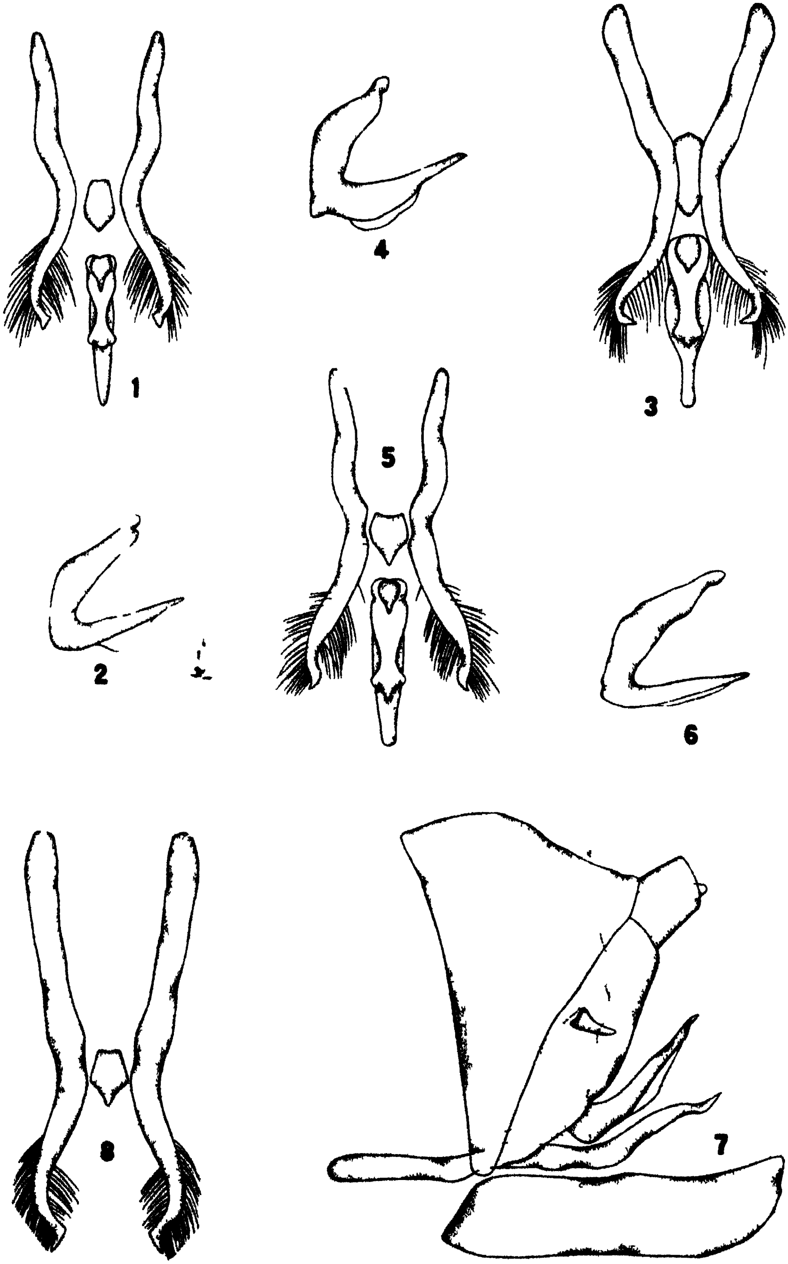


PLATE V.

1. Lateral aspect of genitalia of *Thelia bimaculata.*
2. Dorsal aspect of genitalia of *Thelia bimaculata.*
3. Dorsal aspect of genitalia of *Micrutalis calva.*
4. Lateral aspect of genitalia of *Micrutalis calva.*
5. Dorsal aspect of genitalia of *Acutalis tartarea.*
6. Lateral aspect of genitalia of *Acutalis tartarea.*
7. Lateral aspect of *Telamona pyramidata.*
8. Styles and connective of *Telamona pyramidata.*

PLATE V.

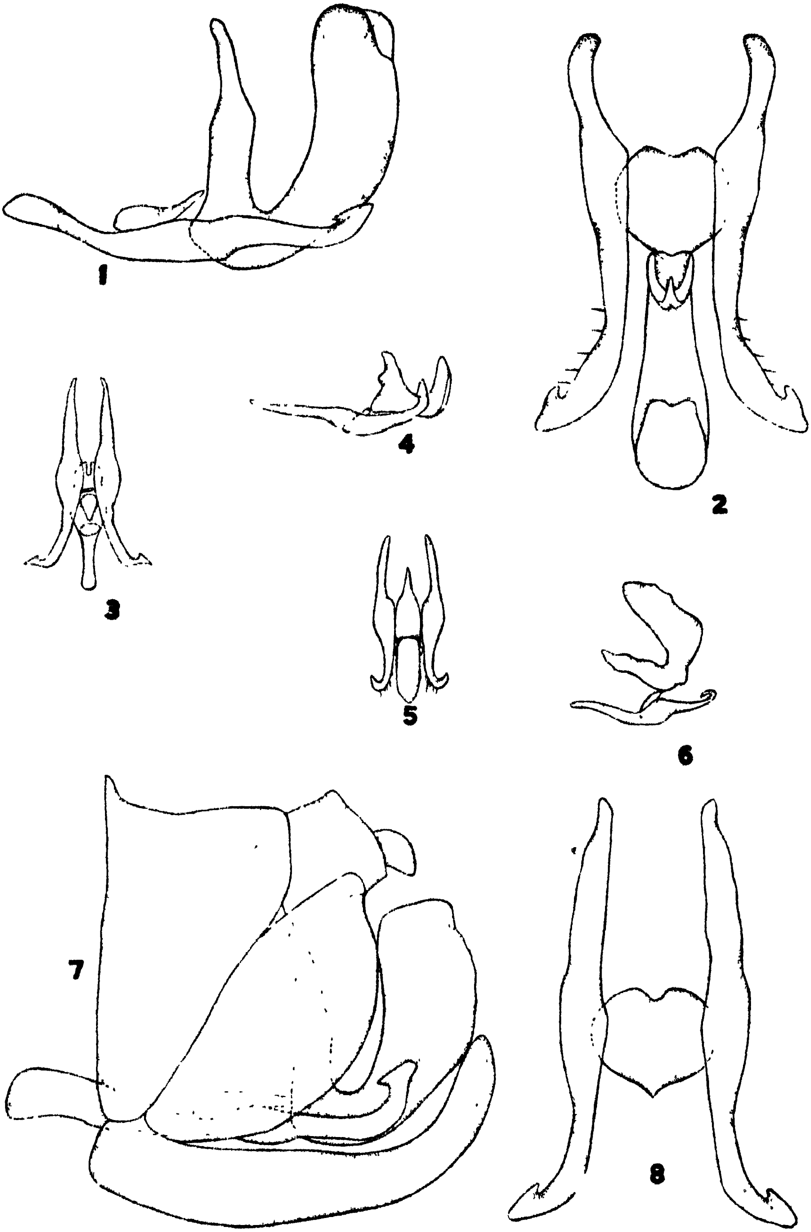


PLATE VI.

1. Lateral aspect of genitalia of *Ophiderma salamandra.*
2. Dorsal aspect of genitalia of *Ophiderma salamandra.*
3. Lateral aspect of genitalia of *Publilia modesta.*
4. Dorsal aspect of genitalia of *Publilia modesta.*
5. Dorsal aspect of genitalia of *Entylia concisa.*
6. Lateral aspect of genitalia of *Entylia concisa.*
7. Dorsal aspect of genitalia of *Vanduzea triguttata*
8. Lateral aspect of genitalia of *Vanduzea triguttata.*
9. Lateral aspect of genitalia of *Campylenchia latipes.*
10. Ventral aspect of genitalia of *Campylenchia latipes.*
11. Dorsal aspect of genitalia of *Enchenopa binotata.*
12. Lateral aspect of genitalia of *Enchenopa binotata*

PLATE VI.

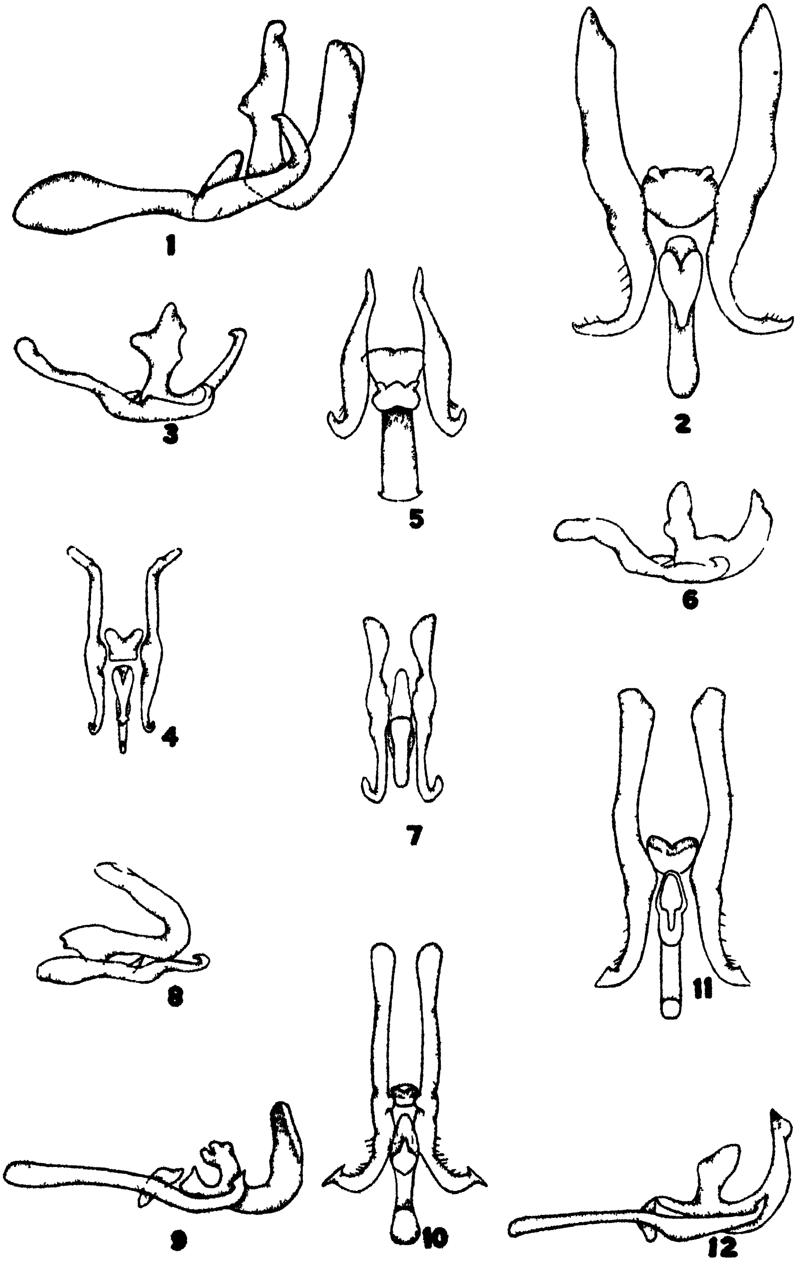
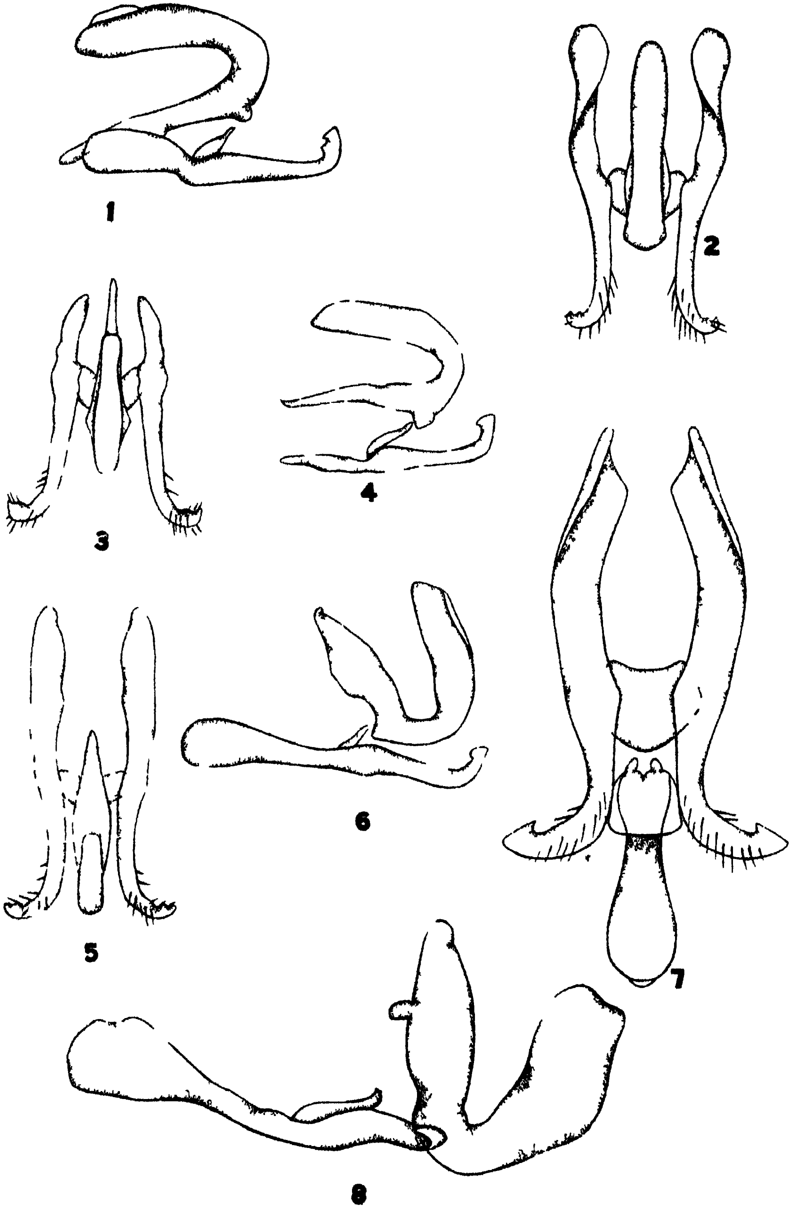


PLATE VII.

1. Lateral aspect of genitalia of *Smilia camelus*
2. Dorsal aspect of genitalia of *Smilia camelus*
3. Dorsal aspect of genitalia of *Cyrtolobus querci.*
4. Lateral aspect of genitalia of *Cyrtolobus querci.*
5. Dorsal aspect of genitalia of *Cyrtolobus vau*
6. Lateral aspect of genitalia of *Cyrtolobus vau*
7. Dorsal aspect of genitalia of *Telamona viridia*
8. Lateral aspect of genitalia of *Telamona viridia*

PLATE VII



INDEX.

THE

KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV, No. 4—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 4.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 4.

The Genus *Acinopterus* (Homoptera, Cicadellidæ).

BY PAUL B. LAWSON,
Professor of Entomology, University of Kansas.

INTRODUCTION.

THE genus *Acinopterus* was erected by Van Duzee in 1892 to accommodate the species *Acinopterus acuminatus*. Later, in 1895, Baker described a single specimen as *Phlepsius inornatus*, a species which Van Duzee in his catalogue lists as *Acinopterus acuminatus* var. *inornatus*. Finally, in 1903, Ball described three varieties of the typical species of the genus, the first of which, variety *variegatus*, Van Duzee made a synonym of Baker's variety *inornatus*. Thus up to the time that the writer undertook this study, one species and three varieties were recognized as comprising the membership of this genus. The results of the study show that we now have at least eight species and one variety. One or two other species are probably represented in the material at hand, but because of the scarcity of specimens it was not thought best to describe them as new species.

The writer is indebted to the following workers for very kindly loaning him the material studied: Mr. E. L. Dickerson, Mr. George G. Ainslie, Mr. F. H. Lathrop, Prof. J. G. Sanders, Dr. Dwight M. De Long, Mr. C. E. Olson, Mr. Edmund H. Gibson, Prof. H. O. Osborn, and Dr. E. D. Ball. The work done is based for the most part on the many specimens from the collection of Doctor Ball, who not only loaned him all his own material, but also the types in the collection of the Iowa State Agricultural College, and in addition was a great help in making suggestions and giving information as to distribution and host plants. To Mr. E. H. Gibson and Mr. W. L. McAtee the writer owes the privilege of examining the collection

of the National Museum, including the type of Baker's *inornatus*. Through the kindness of Dr. J. Chester Bradley, the material at Cornell University was studied, and Prof. C. P. Gillette kindly permitted the examination of the collection of the Colorado Agricultural College.

DISTRIBUTION.

As far as our present knowledge goes, the members of this genus have hitherto been taken only in the United States and Mexico, a single specimen at least having been collected as far south as Yucatan. In our country it is for the most part southern and western in its distribution. This, along with its occurrence in Mexico, would indicate its probable presence throughout Central America and perhaps in the northern portion of South America. For this last statement, however, there is no certain data. The genus is, therefore, both Nearctic and Neotropical.

The following states have yielded specimens of this genus: New Jersey, Maryland, District of Columbia, North Carolina, South Carolina, Virginia, West Virginia, Florida, Alabama, Mississippi, Tennessee, Arkansas, Missouri, Kansas, Oklahoma, Colorado, Utah, Washington, California, Arizona, Texas and Georgia.

HOST PLANTS.

Very little information is available as to the specific plants on which the members of this genus feed. Most of the specimens collected were taken while sweeping grasses or weeds. De Long reports *Acinopterus acuminatus* as abundant on grasses in Tennessee. Ainslie took specimens from blue grass. Doctor Ball believes that *A viridis* var. *variegatus* feeds on wild geranium. A single specimen of *A. angulatus* was swept from *Sphæralcea angustifolia*. A label on a specimen of *A. acuminatus* from Oklahoma states that it was taken from *Amphiachyris*, while another specimen from Rosser, Tex., was taken from *Tetraneuris*. Evidently most of the members of the genus are either grass feeders or else have as their hosts various weeds found in grassland. Much more careful collecting will need to be done before we can be certain of the specific hosts.

DESCRIPTION OF THE GENUS.

The following is Van Duzee's description of the genus:

General appearance of *Allygus*, but with the elytra strongly narrowed posteriorly, and the tip acute.

Head narrower than the pronotum, rounded, or somewhat produced before,

with the apex subacute, hind edge broadly concave. Vertex rather short, sloping, convex or more or less impressed behind the apex, surface punctured, the anterior submargin obscurely transversely rugose, passage to the front rounded. Front rather broad, at the base slightly encroaching upon the apex of the vertex, suddenly narrowed at tip. Clypeus much widened apically. Loræ large. Cheeks wide. Pronotum broad and rather short, anterior edge broadly arcuate, posterior nearly straight; sides long, oblique, carinated; lateral angles prominent, latero-posterior rounded. Scutellum rather small. Elytra narrow, lanceolate at apex, the tip acute, appendix wanting; sutural edge straight to the extreme tip; costal and apical margins continuous; apical areoles five, inner small, oblique, second largest, reaching the extreme tip; third and fourth small; fifth, or stigmatal, long and usually crossed by one or two transverse veinlets; first and second sectors united by but one transverse nervure, but there are usually three or four connecting the outer claval nervure with the claval suture; all the nervures strong; costa feebly convex. Supernumerary cell of the wings present. Otherwise as in *Athysanus* and *Allygus*.

The above description needs modification to enable it to include the several species in which the tegmina, while visibly narrowed apically, do not end in an acute tip, the sutural margin in these cases not continuing on straight to the extreme apex, but meeting the costal margin to form a rather broadly rounded tip. The writer, therefore, proposes the following generic description:

Head usually narrower than pronotum, rarely as wide. Vertex rounded or distinctly angulate, usually impressed behind the apex, sloping, broadly rounding with the front. Front broad basally, much narrowed apically. Clypeus widened apically. Loræ large, nearly reaching margin of the wide genæ ventrally. Pronotum wide, over twice as wide as long, anterior and posterior margins nearly parallel, latter usually more nearly straight; lateral and humeral margins distinct; disc transversely wrinkled. Scutellum finely granular and with distinct transverse impressed line. Tegmina moderately long, apex always narrowed, sometimes to an acute tip. Venation distinct. Of the five apical cells M_4 is the largest, but it, along with Cu_1 and R_2, is frequently divided by cross-veins, R_2 being so regularly divided that probably both R_1 and R_2 are present. Cell 2d M is not divided by a cross-vein. Veins 1st A and 2d A almost always connected by one or more cross-veins. Valve of male always hidden under last ventral segment; plates usually long but never equaling pygofers. Female, last ventral segment large, always bearing a median notch.

SYSTEMATIC TREATMENT OF THE SPECIES.

KEY TO SPECIES.

A. Apex of tegmina strongly acute; costal margin straight clear to tip.
- B. Brownish or greyish species.
  - C. Darker and larger species.
    - D. Male plates long and narrow, parallel-margined, apices rounded; last ventral segment of female without lateral angles. *acuminatus* Van D.
    - DD. Male plates broad and shorter, apices distinctly divergent; last ventral segment of female with distinct lateral angles. *angulatus* n. sp.
  - CC. Lighter and more slender species. *inornatus* (Bak.).
- BB. Greenish species. *productus* n. sp.

AA. Apex of tegmina rounded; costal margin not running straight clear to tip.
- B. Species brownish or greyish, not distinctly green.
  - C. Species large; last ventral segment of female strongly produced medially. *brunneus* Ball.
  - CC. Species smaller; last ventral segment of female normally produced.
    - D. Species with elytra distinctly variegated. *viridis* var. *variegatus* Ball.
    - DD. Species with elytra not variegated *pallidus* n. sp.
- BB. Greenish species.
  - C. Species larger; plates of male tapering and distinctly divergent apically. *viridis* Ball.
  - CC. Species smaller; plates of male parallel-margined and but slightly divergent apically. *obtutus* n. sp.

Acinopterus acuminatus Van D.

(Pl. VIII, fig. 1; pl. IX, fig. 1; pl. X, fig. 1; pl. XI, fig. 1; pl. XII, figs. 1, 2.)

Acinopterus acuminatus Van D., Psyche, vi, p. 308, 1892

Acinopterus acuminatus G. & B., Hemip. Colo., p. 94, 1895

Acinopterus acuminatus Van D., Bul. Buf. Soc. Nat. Sci., viii, No. 5, p. 69, 1907; ix, p. 225, 1909

Acinopterus acuminatus Osb., Ohio Nat., ix, p. 466, 1909.

Acinopterus acuminatus Smith, Cat. Ins N. J., edn. 3, p. 105, 1910.

Acinopterus acuminatus Barb., Bul. Am. Mus. Nat. Hist., xxxiii, p. 534, 1914.

Acinopterus acuminatus Van D., Trans. San Diego Soc. Nat. Hist., ii, p. 54, 1914.

Acinopterus acuminatus Metc., Jl. Elisha Mitchell Sci. Soc., xxxi, p. 23, 1915.

Acinopterus acuminatus De L., Tenn. St. Bd. Ent., Bul. 17, p. 89, 1916.

Acinopterus acuminatus Van D., Cat. Hemip. N. A., p. 675, 1917.

Acinopterus acuminatus Lathr., S. C. Agr. Exp. Sta., Bul. 199, p. 102, 1919.

Acinopterus acuminatus Laws., Kans. Univ. Sci. Bul., xii, p. 207, 1920.

The following is the original description of this species:

Fulvous brown tinged with dull green or yellowish, elytral nervures pale, brown-margined. Length, 5-6½ mm.

Head pale. Front with about eight brown arcs, more or less distinct. Pronotum feebly calloused on the anterior margin, with a few shallow impressions arranged parallel to the edge, more obvious in the males; lateral margin as long as the latero-posterior, acutely carinated; disc posteriorly obscurely wrinkled. Basal angles of the scutellum with a brownish triangular spot more or less apparent. Pectoral pieces usually more or less invaded with blackish, sometimes pale and immaculate. Legs pale, or suffused with

sanguineous. Abdomen pale, frequently black above, excepting the broad lateral margins; infuscated on the basal and apical segments of the venter in the females; slightly suffused with a pale median line in the males. Elytra pale fulvous, frequently whitish hyaline on the disc of the costal and some of the discal areoles of the corium, and on the inner margin of the clavus, the extreme apex clouded with smoky or even blackish; nervures pale, edged with brownish, the marginal with a fuscous interruption at tip; claval suture brown. Wings smoky, iridescent, nervures fuscous.

Genitalia. Male: Valve wanting. Plates long and narrow, a little longer than the last ventral segment, about one-third wider at base than at their obtusely lanceolate, divergent tips. Pygofers twice the length of the plates, narrowed and obtusely pointed at apex, armed beyond the plates with numerous stout spines. Female: Last ventral segment rather long, hind edge with a shallow median notch, either side of which is a broadly rounded lobe, retreating at the outer angles. Pygofers rather broad, their subacute apex moderately exceeded by the oviduct.

Described from 5 males, 3 females. Maryland, September 29 and August 4, on pines (Uhler); North Carolina (Osborn); New Jersey (Uhler); mountains of northwest Colorado (Gillette); California (Coquillett).

In a male from California the lower surface of the femora is black. A female from North Carolina has the disc of the elytra white-pruinose, and all the specimens exhibit considerable variation in the extent of the black markings.

The writer gives the following description:

A large, rather robust, brownish species, ranging from a greyish-brown to a usually dark-brown color. Length, 5 to 7 mm.

Form. Head distinctly narrower than the pronotum. Vertex usually distinctly produced medially, about half longer at the middle than next the eyes and about twice as broad as long. Front broad, loræ large, cheeks wide, clypeus widened apically. Pronotum over twice as wide as long, anterior margin usually a little more curved than posterior, the lateral and humeral margins subequal, the disc transversely wrinkled. Scutellum large, the surface granular. Tegmina moderately long, the costal margin running straight clear to the apex, forming an acute tip.

Color. Vertex, pronotum and scutellum brownish to olive green, the scutellum with basal angles and three longitudinal lines, light. Tegmina usually shining dark brown, sometimes lighter. When dark brown the nervures are lighter and some of the cells, especially along the costa and on the clavus, are subhyaline or greenish. Light specimens have the viens, especially apically, bordered with brown. Face olive green, unmarked, or with faint arcs on the front. Below olive green, marked more or less with dark brown or black, especially on the thorax, coxæ and tergites of the abdomen.

External genitalia. Female: Last ventral segment twice as long as preceding, broad basally, lateral margins rounding to slightly notched and produced posterior margin; pygofers bearing a few scattered spines and slightly exceeded by ovipositor. Male: Valve not visible; plates long and narrow, parallel-margined, obtuse apices somewhat divergent and greatly exceeded by spiny pygofers.

Internal male genitalia. Styles with margins of anterior half sinuately tapering, distal half stout and strongly curved; the large, club-shaped and coarsely granular apices strongly diverging. Connective small, heart-shaped, with the excision wide and the apex broadly rounding. Œdagus broad basally, narrowing to the middle, bearing two small basal processes and a larger apical one near the tip of which, on the ventral surface, is the fimbriated opening of the penis.

Distribution. This species is largely southern and eastern in its distribution. The many specimens examined by the writer, in addition to those mentioned by Van Duzee, are distributed as follows: Charter Oak, Pa. (J. N. Knull); Pt. Royal, Harrisburg, Rockville, Pa. (J. G. Sanders); Lakehurst, N. J. (J. B. Weiss); Great Falls, Md., Berkeley, W. Va., Ft. Royal, Va., Washington, D. C. (Heidemann); Orangeburg, S. C. (F. H. Lathrop); Kansas City, Mo. (F. Rogers); Bisc Bay, Jacksonville, Fla., Gainesville, Fla. (C. J. Drake); Ardmore, Okla. (F. C. Bishopp); Jacksonville, Tex. (W. D. Pierce); Boerne, Tex. (F. C. Pratt); Victoria, Rosser, Tex. (J. D. Mitchell); Kushla, Ala. (A. H. Sturtevant); Alabama, Florida, Mexico (C. F. Baker); Knoxville, Nashville, Tenn. (W. B. Cartwright, C. C. Hill); Nashville, Covey Spring, Chattanooga, Tenn. (Geo. G. Ainslie); Colliersville, Clarksville, Paris, Lexington, Tenn. (Dwight M. De Long); Agricultural College, Mississippi (H. E. Weed); Cherokee, Bourbon and Miami counties, Kansas (R. H. Beamer); Virginia, labeled *Jassus tructilis*, (Uhler); Spring Creek, Okefinokee Swamp, Bainbridge, Ga. (J. C. Bradley); Little Rock, Ark.; Capa, S. D.

E. L. Dickerson reports what are presumably this species from Cologne, Lakehurst and Egg Harbor, N. J.

Remarks. The writer has examined the three type specimens, one male and two females, of *Acinopterus acuminatus* from the collection of the Iowa State College, and the female type from the Cornell University collection. The two female specimens from Maryland and Virginia are clearly of a different species from the male and female from California, as shown by a comparison of the last ventral segment of the two females. It seems evident, though, that the majority of the eight specimens from which Van Duzee described the species were from the East or Southeast, and that he evidently meant to describe a species with such a distribution. Accordingly these eastern females are retained as types of this species, while the two California specimens, along with a large amount of western material, are placed in the following species, which not only is clearly western in its distribution, but is decidedly different as to the genitalia of both males and females from the above species.

Acinopterus angulatus n. sp.

(Pl. VIII, fig. 8; pl. IX, fig. 3; pl. X, fig. 2; pl. XI, fig. 4; pl. XII, figs. 5, 6.)

A smaller species than the preceding, varying from light to dark brown in color, but uniformly lighter than *acuminatus* and lacking its olive-green tinge. Length, 5 to 6.25 mm.

Form. Head broad, scarcely narrower than prothorax. Vertex broad and short, over twice as wide as long, about one-third longer at middle than next the eyes, anterior margin rounded or slightly angulate, sloping, and with an impressed line behind the apex. Front broad and short, loræ, clypeus and genæ characteristic of the genus. Pronotum over twice as wide as long, anterior margin broadly convex, posterior margin shallowly concave, lateral and humeral margins distinct, the disc transversely wrinkled. Scutellum finely granulated, the transverse impressed line curved and distinct. Tegmina with sutural margin running straight clear to the tip, forming an acute apex. Venation distinct, with from one to several cross-veins between the first and second anal veins.

Color. Vertex, pronotum and scutellum brown or yellowish brown. Scutellum with basal angles and three longitudinal lines, light. Elytra brown, the veins margined with darker brown, so that many of the cells, especially along the costa and apically, appear light. Face brown; front with eight pairs of dark-brown lines, which are longest above and shortest below, leaving the middle portion unmarked. Below brown, but with parts of thorax, the coxæ and femora of the meso- and metathoracic legs and the dorsum of the abdomen usually black or dark brown.

External genitalia. Female: Last ventral segment twice as long as preceding, the posterior margin varying from slightly concave to slightly convex, but always with a slight median notch and forming very distinct lateral angles with the long lateral margins. Pygofers moderately wide, sparsely spined, exceeded slightly by the ovipositor. Male: Last ventral segment long, hiding the valve. Plates broad, about the length of the last ventral segment, only slightly narrowing to the obtuse tips which are divergent medially, but have distinct lateral angles. Pygofers with a few stout spines and exceeding the plates by about two-thirds the length of the latter.

Internal male genitalia. Styles with rather small and pointed anterior ends, widest at point of the distinct process to the connective, then strongly curved to the very wide apices, which are quite granulated and clearly concave between the outer angle and the larger, more produced inner apex. The outer margin bears a few small spines. Connective heart-shaped, the apex quite broad. Œdagus of the pattern characteristic of the genus, the basal processes well developed and toothed, the terminal process very long, clearly showing the penis, which opens at the fimbriate extreme apex of the process.

Distribution. With one exception, a specimen from Washington, D. C., all the material at hand came from the South and West. A single specimen was taken in Yucatan, many specimens coming from other parts of Mexico. We are evidently safe in calling it a southwestern species, which may possibly extend its range into the southeastern states. The following are the locality records of the

material studied: Riverside, Chino, San Diego, Ontario, Visalia, Tia Juana, Oroville, Caliente (Ball); Hamilton (no collector's name); Los Angeles (Coquillett and A. Koebele); Whittier, Brawley (H. O. Osborn); all from California, along with a number of specimens taken by C. F. Baker; Vera Cruz (no collector's name) along with two specimens taken by Gillette and a series by Baker, all from Mexico; Victoria (J. D. Mitchell), Orizaba (H. Osborn), College Station (no collector's name), Brewster county (Mitchell and Cushman), all from Texas. Also a single specimen taken at Progresso, Yucatan, by Frederick Knab, and one taken at Washington, D. C.

Holotype, male, Ontario, Cal. Collection of E. D. Ball.

Allotype, female, Ontario, Cal. Snow collection, University of Kansas.

Paratypes, male, Visalia, Cal., and female, Chino, Cal., in collection of E. D. Ball; male, Riverside, Cal., and female, Chino, Cal., in Snow collection; male, Whittier, Cal., and female, Brawley, Cal., in collection of H. O. Osborn.

Acinopterus inornatus (Bak.)

(Pl. VIII, figs. 3, 4 [type], 5; pl. IX, figs. 8, 9; pl. X, fig. 6; pl. XI, fig. 7; pl. XII, figs. 11, 12.)

Phlepsius inornatus Bak., Psyche, vii, Suppl. i, p. 13, 1895.
Acinopterus acuminatus var. *inornatus* Van D., Cat. Hemip. N. A., p. 675, 1917.

The following is the original description.

Phlepsius inornatus, n. sp. Differing from all other species of the genus in being entirely destitute of elytral reticulations or other markings. Length of male, 6 mm.

Male: Head narrower than the pronotum. Face a twelfth wider than long; clypeus one-half longer than broad, somewhat constricted before the base, basal suture strongly curved, apex slightly concave; loræ as long and two-thirds as broad as clypeus; margin of genæ rather slightly incurved below the eye, below this strongly convex, thence slightly incurved to tip of clypeus. Front an eleventh longer than broad, somewhat less than twice the length of the clypeus, broad below, the sides very slightly incurved at the antennæ. Disc of the vertex flat, length at middle once and a half that next the eye, width between the eyes once and a half the length. Width of the pronotum two and a third times the length, the length about once and two-thirds that of the vertex, curvature nearly two-fifths of the length, posteriorly irregularly transversely wrinkled. Scutellum and elytral venation normal. Plate not visible, valves two and a half times longer than broad at base, slightly narrowed at apex, blunt at tips, without hairs. Pygofers one-half longer than valves, pointed at tips, their whole outline subtriangular, provided on disc of lower surface with several rather long whitish spines arranged in a single longitudinal row.

Color very pale yellowish, deeper on the abdomen. Pronotum with five very indistinct longitudinal whitish bands. Elytra translucent, pale milky

white, with indistinct smoky clouds on the discs of some of the apical and anteapical areoles. Veins white, claval suture brownish. Face and legs tinged with greenish, some of the white tibial spines brown tipped. Tarsal joints at apices dark. Dorsal abdominal segments, except lateral and apical margins, blackish.

Described from a single male taken at San Augustine (Ckll. 2140). In form this insect very closely resembles *P. superbus* and in structure is strictly congeneric with it. It differs very widely, however (and this is a generic difference according to Van Duzee's synoptic table of the genera), in that it does not possess the elytral reticulations or other markings so characteristic of the genus. On a very superficial examination it might be taken for a Chlorotettix, but its general form, stronger build, and lengthened vertex are strictly Phlepsiid.

The writer gives the following description:

A rather slender and light-colored species which sometimes may be rather dark. Length, 5 to 6.5 mm.

Form. Head distinctly narrower than the pronotum. Vertex varying in length, but usually about twice as wide as long and half longer at the middle than next the eye; disc sloping and with the impressed line behind the apex. Face as in the other members of the genus. Pronotum over twice as wide as long, the anterior margin more strongly curved than the posterior, the lateral and humeral margins about equal. Scutellum of average size, finely granulated, and with distinct transverse impressed line. Tegmina long and narrow, sutural margin extending straight clear to tip, forming an acute apex; venation usually distinct, though sometimes rather weak, with from one to several cross-veins between the first and second anal veins.

Color. Yellowish or yellowish grey. Pronotum with five pale and sometimes indistinct lines. The tegmina vary considerably, being sometimes almost colorless till near the tip, while in others the veins are margined lightly with brown, especially at the margins, but in all cases some of the apical cells are more or less darkened. The darkened tips of the veins along the sutural and costal margins sometimes give the elytra a variegated appearance. Beneath this species is usually light except for the darkened dorsum of the abdomen.

External genitalia. Female: Last ventral segment over twice as long as the preceding, posterior margin distinctly but roundingly produced medially, but with the small median notch characteristic of the genus. Pygofers moderately wide, sparsely spined, and slightly exceeded by the ovipositor. Male: Last ventral segment longer than the preceding, hiding the valve. Plates long and fingerlike, about the length of the last ventral segment, slightly narrowed to the somewhat diverging but rounded tips. Pygofers bearing a few stout spines and exceeding the plates by about two-thirds the length of the latter.

Internal male genitalia. Styles wide basally and with strong process to connective; apically strongly curved and clublike, the apical portion of the club with distinct and large granulations, giving it a rough appearance. Connective heart-shaped, the excision wide and shallow, the apex rounded. Œdagus rather small but stout, the upper part much like an inverted boot, the heel distinctly cleft; the paired basal processes about half the length of the apical process, their lower edges serrate; the terminal process stout, the penis opening at the fimbriate tip.

Distribution. This species is evidently a southwestern form, for all the material at hand was taken in this region. The following are the locality records of the twenty-two specimens examined: Type specimens from San Augustine, N. M. (C. F. Baker); Ontario, Riverside, Cal. (E. D. Ball); Santa Rita mountains (F. H. Snow), Galiuro mountains (H. G. Hubbard), Phoenix (E. D. Ball), Sabino Canyon, St. Catalina mountains (E. L. Dickerson), all from Arizona; Brewster county, Texas (Mitchell and Cushman).

Remarks. As far as the writer knows, this species has been known hitherto only from the type. In the material gathered for the study of the genus he found a number of similar specimens, which, while differing in some ways, particularly in the length of the vertex and the extent of the elytral markings, are yet thought to be representatives of this species, for a careful study of the genitalia of several males revealed no differences, although the vertices of the specimens were quite unlike. Also the specimens show a complete range in color from that of the very light type specimen to forms that are distinctly brownish. While frankly having some doubt as to the specific identity of all the material named thus, the writer feels it better to call them all the same species rather than to describe new species on insufficient material.

Acinopterus productus n. sp.

(Pl. VIII, fig. 6; pl. IX, fig. 2; pl. X, fig. 3; pl. XI, fig. 3; pl. XII, figs. 13, 14.)

A distinctly greenish species, differing from other green forms by the acute apex of the tegmina and the produced vertex.

Form. Head distinctly narrower than pronotum. Vertex less than twice as wide as long, at least half longer at the middle than next the eye, the apex rounded and with an impressed line parallel with the margin. Face characteristic of the genus. Pronotum short, well over twice as wide as long, the anterior margin more strongly curved than the posterior, the lateral and humeral margins about equal, the disc transversely wrinkled. Scutellum with the usual granular surface and impressed line. Tegmina long and rather narrow, the costal margin running straight clear to the tip, forming an acute apex, and with the nervures distinct, the first and second anal veins usually united by several cross-veins.

Color. The entire insect is green except for the darkened apices of the elytra and the yellowish or pinkish legs. The nervures stand out as a lighter green than the cells of the tegmina.

External genitalia. Female: Last ventral segment over twice as long as the preceding, the medially produced posterior margin with the usual small notch, the lateral margins rounding with the posterior. Pygofers rather robust, sparsely spined, and slightly exceeded by the ovipositor. Male: Valve hidden by the long last ventral segment. Plates longer than last ventral segment, fairly wide basally, tapering to the divergent and rounded but com-

paratively narrow apex. Sparsely bristled pygofers exceeding plates by about two-thirds the length of the latter.

Internal male genitalia. Styles of usual form, widest at point of process to connective, apically club-shaped, the granulated and blunt apices slightly but clearly concave. Connective heart-shaped, the excision fairly deep. Œdagus with body as in other species, the basal processes small, the terminal process of medium diameter and length.

Distribution. The eight specimens at hand when this species was described all came from California and Arizona. They were all taken by Dr. E. D. Ball. The California specimens are from Imperial, Beaumont and Riverside, while the two Arizona specimens are from Phoenix.

Holotype, female, Imperial, Cal., in collection of Doctor Ball.

Allotype, male, and paratype, female, both from Imperial, Cal., in the Snow collection, University of Kansas.

Paratypes, male from Imperial and female from Beaumont, Cal., in collection of Doctor Ball.

Acinopterus brunneus Ball.

(Pl. VIII, fig. 2; pl. IX, fig 5; pl. X, fig 7; pl. XI, fig. 6; pl XII, figs 9, 10)

Acinopterus acuminatus var. *brunneus* Ball, Can. Ent., xxxv, p. 231, 1903.
Acinopterus acuminatus var. *brunneus* Van D., Cat. Hemip. N. A, p 675, 1917.

The following is the original description:

A. acuminatus, var. *brunneus*, n. var. Slightly larger than the preceding variety. Vertex, pronotum and scutellum pale green, washed with cinnamon brown. Elytra pale cinnamon brown, slightly fuscous at tip. Whole insect with a slight tawny iridescence, below pale green.

Described from three specimens from Rifle, Colo., taken by the author.

The writer adds the following description:

A large brownish or greenish-brown species, about the largest member of the genus. Length, 5.5 to 6.75 mm.

Form. Head about as wide as the pronotum. Vertex at least twice as wide as long, one-third longer at middle than next the eye, the anterior margin rounded, and with the characteristic depression behind the apex. Face with all the parts very broad, the loræ nearly reaching the margin of the genæ. Pronotum over twice as wide as long, the anterior margin more strongly curved than the posterior, lateral and humeral margins distinct and about equal, the disc transversely wrinkled. Scutellum as in other members of the genus. Tegmina with rounded apex but more acute than in *viridis*, the venation often less distinct than in other species, and usually with several cross-veins between the first and second anal veins.

Color. Vertex, pronotum and scutellum greenish-brown. Tegmina of same color or darker, the veins of the apical half often being margined with dark brown, giving the tip a darker appearance. Beneath the color is usually as above but sometimes the hind legs and abdomen have a reddish tinge.

External genitalia. Female: Last ventral segment differing from that of any other member of the genus in being extremely produced medially, three times as long as the preceding segment, with the usual small apical excision, and the lateral margins sometimes slightly concave. The broad and spiny pygofers are slightly exceeded by the ovipositor. Male: Last ventral segment long, hiding the valve. Plates long and slender, longer than last ventral segment, their sides straight to the somewhat narrowed but rounded apices. Pygofers long, exceeding plates by about the length of the latter, bearing the usual spines.

Internal male genitalia. Styles stout, apical part nearly of same width throughout and bearing many granulations. Connective as broad apically as basally. Œdagus unlike anything in the genus and very characteristic, the basal processes short and not serrate, the distal process very long, the fimbriate opening of the penis extending back from the extreme tip for a considerable distance. In addition a pair of large ventral and lateral lobes is present that completely cover the basal processes, these lobes being serrate along their ventral margin. The entire dorsal part of the œdagus is also quite different from the corresponding part in the other species of the genus.

Distribution. With the exception of a single specimen taken by Coquillett at Los Angeles, Cal., all the other fourteen specimens examined by the writer are from Doctor Ball's collection. These were taken from the following localities: Rifle, Colo.; Pardman, Salt Lake City, Utah; Ravenna, Cabazon, Riverside, and Beaumont, Cal.

Acinopterus pallidus n. sp.

(Pl. VIII, fig. 10; pl. IX, fig. 4; pl. XI, fig. 2.)

Closely related to the preceding species, but slightly smaller and paler. Length, 5.5 to 6 mm.

Form. Head distinctly narrower than the pronotum. Vertex a little over twice as wide as long, not quite one-third longer at the middle than next the eye, the anterior margin evenly rounded and broadly rounding with the front, the depression back of the apex small. Face very broad, the front fully as broad basally as long, and the genæ quite wide. Pronotum over twice as wide as long, anterior margin but slightly more curved than the posterior, lateral and humeral margins about equal, disc with transverse wrinkles. Scutellum with usual granular surface and transverse impressed line. Tegmina moderately long, the apices more rounded than in preceding species, venation distinct but not conspicuous, and with but one or two cross-veins between the first and second anal veins.

Color. The entire insect, above and below, of a pale greenish-yellow color. Apices of some of the veins along costal margin and at apex margined with black, making the tips of the tegmina appear slightly darkened. The tarsi tend to be brownish.

External genitalia. Female: Last ventral segment produced medially, bearing a shallow median notch apically from which the margins round to the base. Pygofers large, sparsely spined, exceeded by the ovipositor.

Distribution. Described from four specimens taken by Doctor Ball at Cabazon, Cal.

Holotype, female, and two paratypes, females, in collection of Doctor Ball.

One paratype, female, in the Snow collection, University of Kansas.

Remarks. This species stands between *brunneus* and *viridis.* From the former it differs in its smaller size, lighter color, and shorter female ventral segment, while from the latter it differs in being lighter, and in not having the tegminal veins green.

Acinopterus viridis Ball.

(Pl. VIII, fig. 11; pl. IX, fig. 6; pl. X, fig. 4; pl. XI, fig. 5; pl. XII, figs. 7, 8.)

Acinopterus acuminatus var. *viridis* Ball, Can. Ent., xxxv, p. 231, 1903.
Acinopterus acuminatus var. *viridis* Van D., Cat. Hemip. N. A., p. 675, 1917
Acinopterus acuminatus var. *viridis* Laws., Kan. Univ. Sci. Bul., xii, p. 208, 1920.

The following is the original description:

A. acuminatus, var. *viridis*, n. var. Form and structure of the preceding nearly; slightly smaller. Bright grass green both above and below. Eyes and extreme tip of elytra fuscous.

Described from a number of specimens from southern Colorado and Arizona. This is the common form in southern Colorado, where it was taken by E. P. Van Duzee and the author.

The following description is by the writer:

A rather robust greenish species, with or without elytral markings. Length, 5 to 6 mm.

Form. Head distinctly narrower than the pronotum. Vertex about twice as wide as long, one-half longer at the middle than next the eye, anterior margin broadly rounded and with a depression just behind apex. Face with all the sclerites broad. Pronotum over twice as wide as long, anterior margin more strongly curved than the posterior, lateral and humeral margins about equal, the disc transversely wrinkled. Scutellum as in other members of the genus. Tegmina moderately long, the apex narrowed' but rounded, with usually one or two or sometimes several cross-veins between the first and second anal veins and sometimes one or two between the second and third.

Color. Vertex, pronotum and scutellum usually green, though sometimes distinctly yellowish. Tegmina green with the nervures darker green, the latter being sometimes not margined at all or bordered with brown till all the apices of the veins at the sutural margin, along the distal half of the costal margin, and at the apex, are definitely bordered, frequently giving the apex a darker appearance. Below the insect is also green, the tarsi tending to be brownish.

External genitalia. Female: Last ventral segment over twice as long as the preceding, the lateral and posterior margins rounding to the produced apex which bears the usual small median notch. Pygofers stout, sparsely spined, exceeded by the ovipositor. Male: Last ventral segment long, hiding the valve. Plates long and slender, slightly longer than last ventral segment, the bases distinctly wider than the divergent apices. Pygofers broad, sparsely spined, exceeding the plates by about two-thirds the length of the latter.

Internal male genitalia. Styles large, widest at point of process to connec-

tive, distal portion strongly curved and then running straight to the expanded tips, which have the inner angles about right-angled, but the outer angles strongly produced, the distal margin between the two corners being slightly concave. The outer margins of the distal half are roughened and the characteristic granulations appear over the entire apical portion. Connective heart-shaped, the apex broadly rounded. Œdagus very characteristic of the species, having two pairs of basal processes, the upper ones shorter, the lower ones reaching nearly to the tip of the apical process, at the extreme fimbriate tip of which the penis opens. Both pairs of basal processes bear teeth along the margins.

Distribution. All of the twenty-five specimens, except one from Colorado, one from Morton county, Kansas, and one from Ashfork, Ariz. (Barber and Schwarz), were sent the writer by Doctor Ball, who obtained them from the following localities: Soldier, Dixie, Richfield, Monroe, Moab, Utah; Fort Collins, Grand Junction, Delta, Dutch George or Poudre Canyon, Colo.; Coolidge, Kan.; Wenatchee, Wash.; Phoenix, Ariz. There are specimens also in the collection of the Colorado Agricultural College from some of these localities.

Remarks. The specimen from Moab, Utah, seems to be different from the other specimens of this species in that it is lighter in color, has a broader head, and longer and more pointed elytra. There being only one specimen of its kind, however, the writer prefers to place it here to describing it as a new species from a single specimen.

Acinopterus viridis var. *variegatus* Ball.

(Pl. VIII, fig. 7; pl. IX, fig. 7.)

Acinopterus acuminatus var. *variegatus* Ball, Can. Ent., xxxv, p. 231, 1903.
Acinopterus acuminatus var. *inornatus* Van. D., Cat. Hemip. N. A., p. 675. 1917.

The following is the original description:

Acinopterus acuminatus, var. *variegatus*, n. var. Form and structure of the species, but much lighter colored. Vertex, pronotum and scutellum inclined to be reddish, especially in the male. Elytra whitish pruinose, nervures greenish, not margined, except towards apex and along sutural margin, three fuscous points along the suture, and sometimes one on the disc of each elytron.

Described from twenty-four specimens from Colorado and Arizona.

The following is the writer's description:

The members of this variety are like *viridis* except in color.

Color. General color, brown. Vertex, pronotum and scutellum greyish or brownish, sometimes with a reddish tinge. Tegmina pale, but with nervures margined more or less throughout, especially along sutural and costal margins and apically, giving them a decidedly variegated appearance.

Distribution. Eight specimens examined are from Doctor Ball's collection and were taken by him at Fort Collins and Denver, Colo.

In the collection of the Colorado Agricultural College are other specimens from the same localities.

Remarks. The specimens at hand show gradual gradations into the variegated form of *viridis*, which, in its turn, goes by insensible gradations into the pure green form characteristic of the species. An examination of the male internal genitalia of typical *variegatus* and that of a variegated *viridis* showed no differences, and the gradual loss of the tegminal markings into the plain green form would seem to indicate the identity of these two green forms.

Acinopterus obtutus n. sp.

(Pl. VIII, fig. 9; pl. X, fig. 5; pl. XII, figs. 3, 4.)

A rather small green species with a relatively larger vertex than *viridis*. Length, 5.5 mm.

Form. Head distinctly narrower than pronotum. Vertex large, about twice as wide as long, one-half longer at the middle than next the eye, a slight depression just behind the broadly rounded apex which rounds very obtusely with the front. All the sclerites of the face rather broad. Pronotum over twice as wide as long, the anterior margin more curved than the posterior, the lateral and humeral margins about equal, the transverse wrinkles of the disc indistinct. Scutellum with the usual granulated surface and transverse impressed line. Tegmina with the tips broken off in all three of the specimens from which the species is described, but presumably rather rounded apically, judging from the material studied. Claval area with a few cross-veins between the first and second anal veins.

Color. Vertex, pronotum and scutellum green, the scutellum with basal angles and three longitudinal lines, light. Tegmina milky green, the veins light or dark green, and margined more or less with brown. Below the entire insect is green.

External genitalia. Male: Last ventral segment long, hiding the valve. Plates long and narrow, nearly parallel-margined to the somewhat divergent apices, which are exceeded by the bristly pygofers by about two-thirds the length of the former.

Internal male genitalia. Styles of the usual shape, the granular apical portions quite expanded at the tip, which is either straight or slightly concave at the end. Connective nearly round, the basal excision rather deep. Œdagus differing from that of any member of the genus. The body is very wide basally, the heel cleft, then strongly narrowed to the base of the processes, of which the basal pair are short and slender while the distal one is quite long and slender, the penis opening at the extreme fimbriate tip.

Distribution. The three male specimens from which this species is described are all from the collection of Mr. E. L. Dickerson and were taken in the Sabino canyon of the St. Catalina mountains of Arizona.

Remarks. This species is decidedly smaller than the other green species, and the œdagus is so characteristic that on this structure

alone the writer is confidently basing the distinctness of these species. Among the specimens of *viridis* from Colorado and Utah there may be one or two that are the females of this species, but not being as sure of their position as of these three males, they are left in the former group.

Holotype in collection of Mr. E. L. Dickerson.

Paratypes in collection of Doctor Ball and the Snow Collection. University of Kansas.

PLATE VIII.

FIG. 1. *A. acuminatus.*
FIG. 2. *A. brunneus.*
FIGS. 3, 4, 5. *A. inornatus.*
FIG. 6. *A. productus.*
FIG. 7. *A. viridis* var. *variegatus.*
FIG. 8. *A. angulatus.*
FIG. 9. *A. obtutus.*
FIG. 10. *A. pallidus.*
FIG. 11. *A. viridis.*

PLATE VIII.

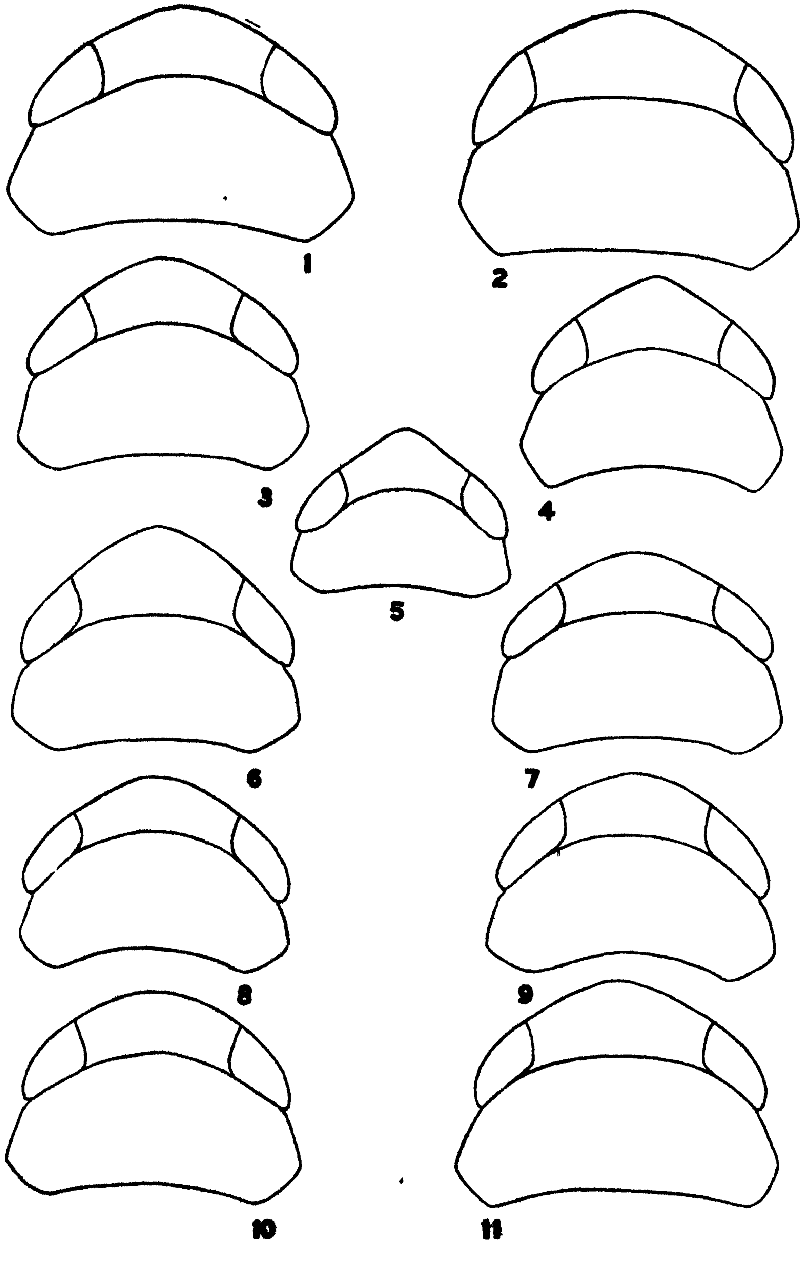


PLATE IX.

FIG. 1. *A. acuminatus.*
FIG. 2. *A. productus.*
FIG. 3. *A. angulatus.*
FIG. 4. *A. pallidus.*
FIG. 5. *A. brunneus.*
FIG. 6. *A. viridis.*
FIG. 7. *A. viridis var. variegatus.*
FIGS. 8 and 9. *A. inornatus.*

PLATE IX.

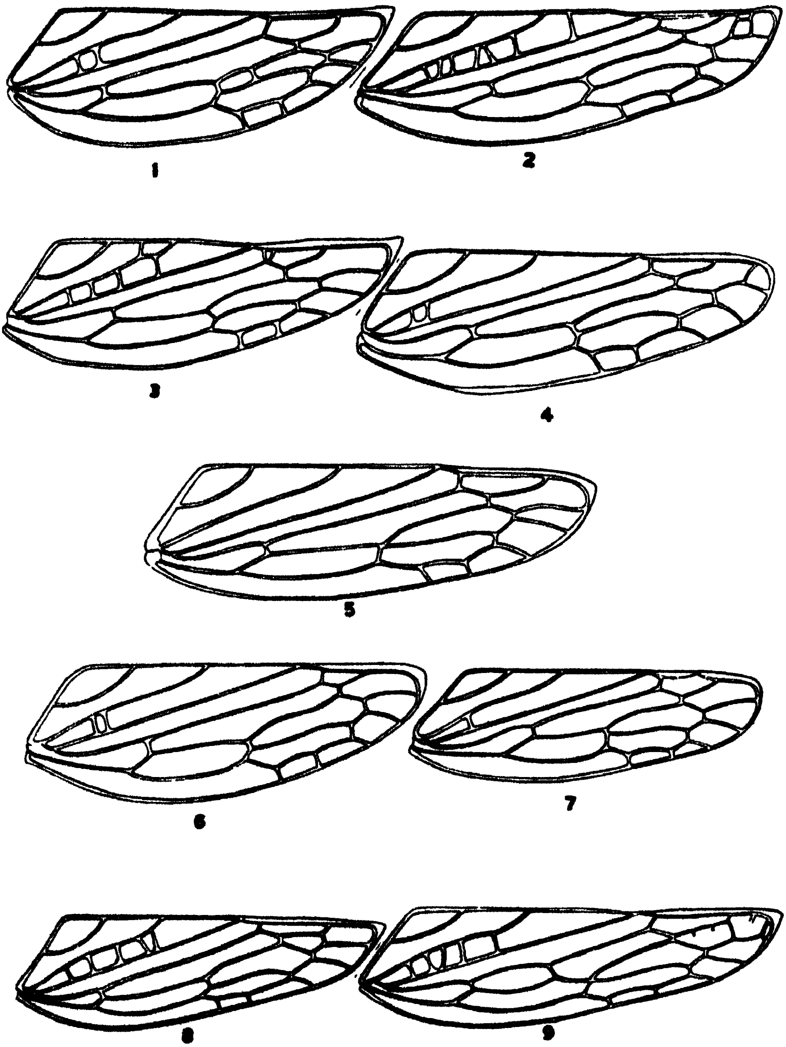


PLATE X.

FIG. 1. *A. acuminatus.*
FIG. 2. *A. angulatus.*
FIG. 3. *A. productus.*
FIG. 4. *A. viridis.*
FIG. 5. *A.* ~~*viridis.*~~ obtutus
FIG. 6. *A. inornatus.*
FIG. 7. *A. brunneus.*

PLATE X.

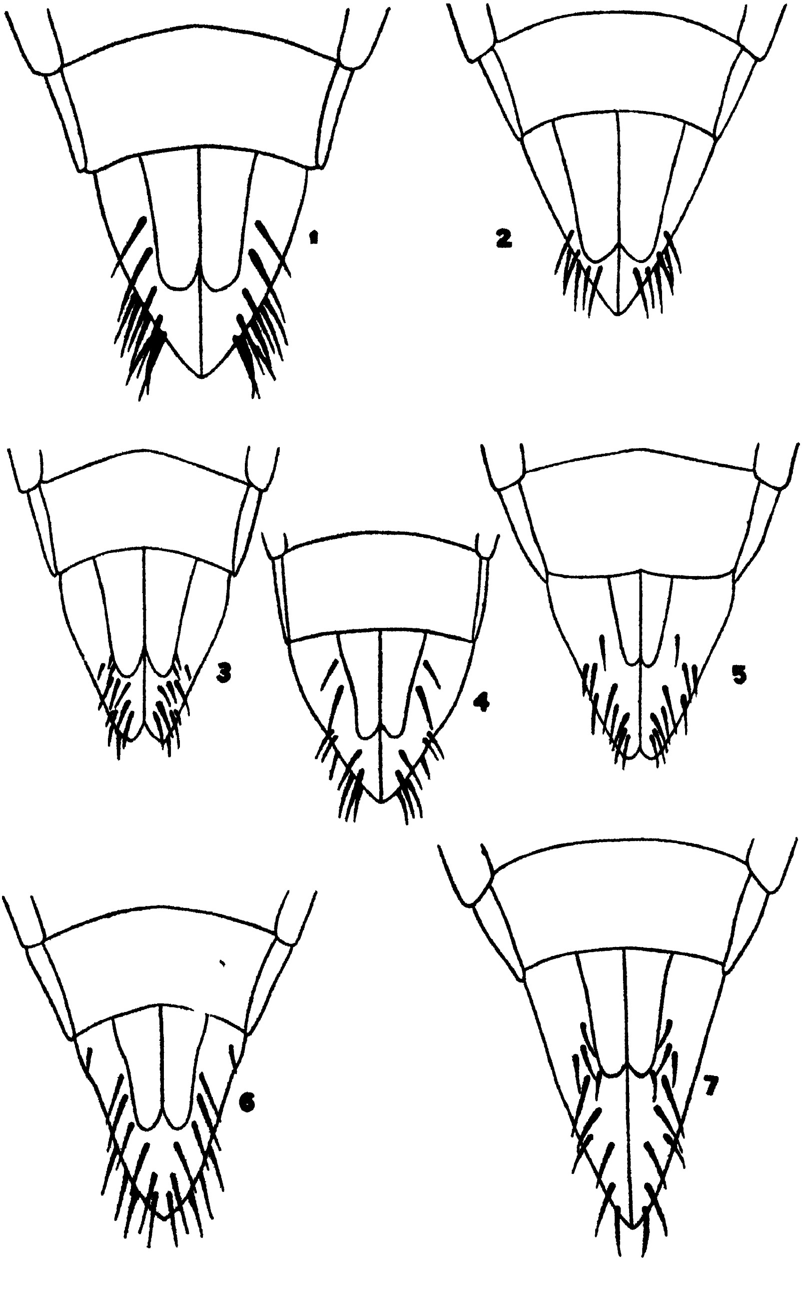


PLATE XI.

FIG. 1. *A. acuminatus.*
FIG. 2. *A. pallidus.*
FIG. 3. *A. productus.*
FIG. 4. *A. angulatus.*
FIG. 5. *A. viridis.*
FIG. 6. *A. brunneus.*
FIG. 7. *A. inornatus.*

PLATE XI.

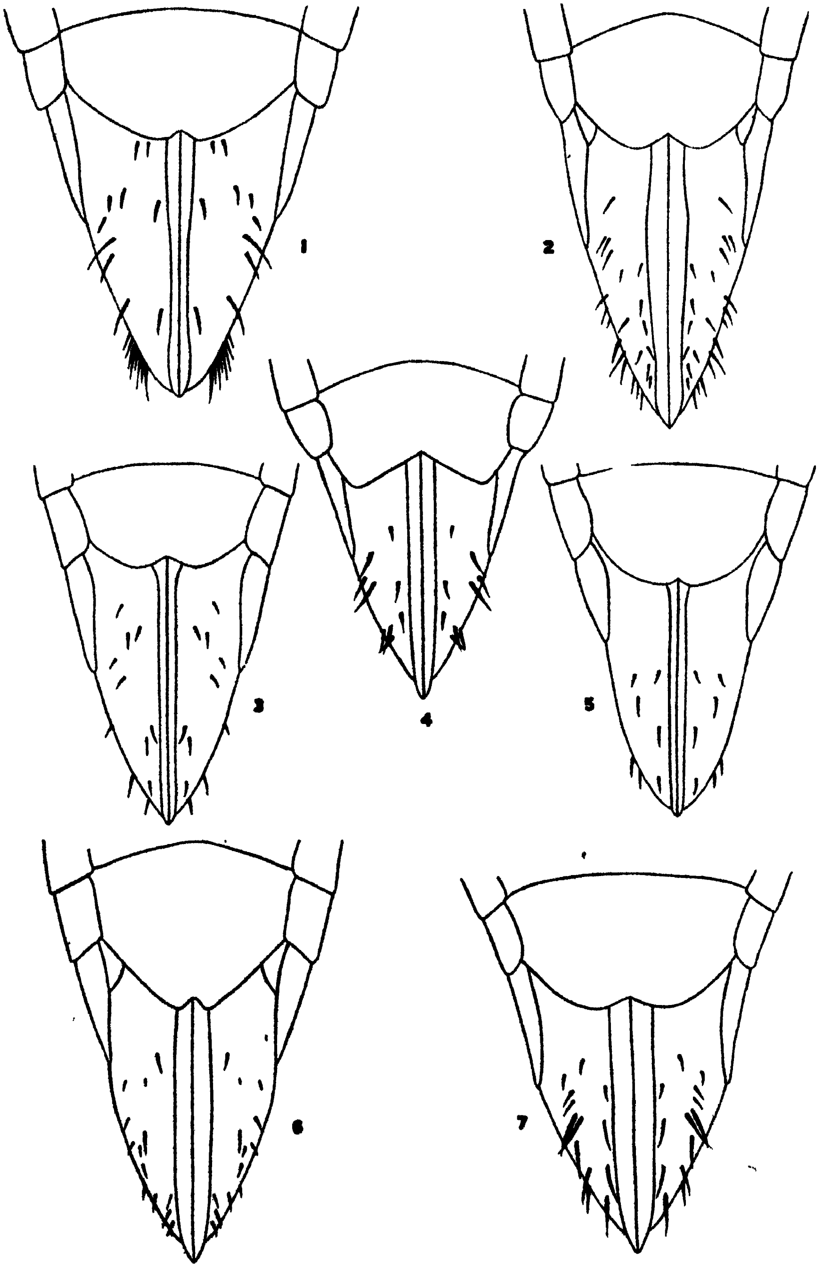
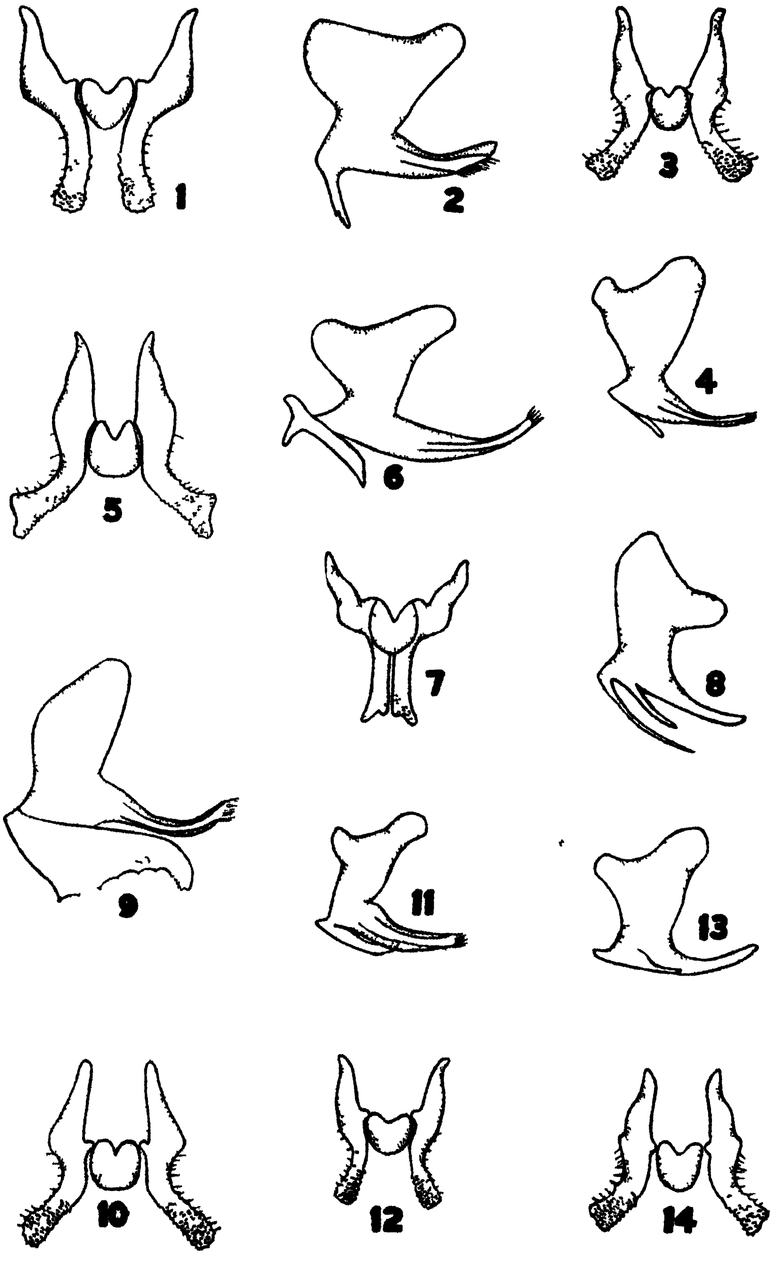


PLATE XII.

FIGS. 1 AND 2. *A. acuminatus.*
FIGS. 3 AND 4. *A. obtutus.*
FIGS. 5 AND 6. *A. angulatus.*
FIGS. 7 AND 8. *A. viridis.*
FIGS. 9 AND 10. *A. brunneus.*
FIGS. 11 AND 12. *A. inornatus.*
FIGS. 13 AND 14. *A. productus.*

PLATE XII



THE

KANSAS UNIVERSITY

SCIENCE BULLETIN

VOL. XIV, No. 5—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 5.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 5.

The Life History of the Toad Bug.

Gelastocoris oculatus Fabr. (Gelastocoridæ).*

BY H. B. HUNGERFORD,

Professor of Entomology, University of Kansas.

INTRODUCTION.

IN MY PAPER on "The Biology and Ecology of the Aquatic Hemiptera"† (pages 49-51) I gave the gist of what was known at the time concerning the habits and life history of the toad bug. Its habitat and feeding habits, together with a brief description of the ovum and fifth nymphal instar were given there.

During the season of 1920 I had an opportunity to gather considerable data relative to these interesting insects. Mrs. Grace Wiley, a student of mine, knowing of my desire to study *Gelastocoris,* sent me a number of living adults from her home in Chanute, Kan., in the autumn of 1919. One of these I kept alive until September, 1920. On May 14, 1920, she sent me a shipment of adults, and again on July 6 another small lot of the bugs. The live insects supplied by Mrs. Wiley thus made possible the notes here reported, and I wish to acknowledge my gratitude to her for her kindness.

THE TECHNIQUE USED IN THE REARINGS.

Tall stenders, or staining jars, of glass about the size of jelly glasses were used. In each of these was placed an inch of sand that had been sterilized by heat. The paired adults were confined in low stenders of various sizes, and the sand searched each day for eggs. The young were isolated in the tall stenders as soon as hatched, for they were cannibalistically inclined, and two young

* Mr. Bueno recognizes this as a new species, *G. accriduus* Ms. I confess I cannot distinguish it from *G. oculatus* Fabr.

† Kansas University Science Bulletin, vol. XI, Dec. 1919; 265 pages, 33 plates.

would get on but a few hours together. The sand was moistened each day, and the jars covered with ground-glass covers. Each nymph was examined daily for molts, which were removed and placed in vials of alcohol or on cotton in small tin boxes, and each instar skin of each insect reared was preserved separately for study. This has provided adequate material for study of structural details of each stage.

We endeavored to determine whether the insects had any choice of soil, by placing them in pans containing sand on one side and sandy loam on the other. Our results were not conclusive. We also used sterilized sandy loam in some of the rearing jars instead of the sand and found it of no advantage.

The insects were fed house flies, plant lice, oscinid flies, cicadellids and many other small insects taken in sweeping the grass upon the campus. Each day the dead carcasses were cleaned out of the rearing jars and freshly killed insects inserted.

Mortality was very high, as a glance at the tables presented below will show, and indicates that some essential factor of their natural habitat was lacking. The fact that 116 nymphs out of 179 died in the first stage, and that they usually succumbed on the date when molting might have been expected to occur, would point to a hazard of ecdysis. An examination of the dates of death of the older nymphs further substantiates this view.

Toward the end of a stadium the nymph always appears plump instead of flat, and so the appearance of the nymph indicates approximately its development. Thus some would become plump in a week and molt; others would develop more slowly.

In spite of the discouragements because of the very high rate of mortality, the tending and study of the rearings were very interesting. Mr. William Hoffman, who assisted me very materially during the latter part of the summer, found the task most absorbing. He fed the nymphs and kept the records with as much interest, care and ingenuity as I could have done, and I desire to acknowledge herewith my indebtedness to him for his services.

HABITAT.

The toad bug is a shore bug, found along the muddy banks of small streams or the sandy beaches by the river. It is a notable example of protective coloration. Specimens taken on muddy banks are dull and slaty grey with indistinct pattern, while those from the sandy beaches are variegated, pebbled and mottled like the sand. Specimens in captivity have been observed to burrow be-

neath the dirt in cloudy weather and remain thus many hours. This habit may be their method of maintaining their geographical position in time of flood. I have observed broad, sandy, barren flats where toad bugs lived become inundated by rapid currents of water for a few hours; nevertheless, when the water receded and the sun came again, here were the bugs as before. There were neither vegetation nor sizable stones for their anchorage, so I suppose they "dug in." They hop about with considerable alacrity when alarmed (one first instar nymph jumped ten inches). They pounce upon their prey, which appears to consist of almost any sort of insect they can capture, from a grouse locust (*tettix*) to a lacebug.

MATING.

There is considerable sexual dimorphism with the toad bug. The abdomen of the male is strongly asymmetrical, as is also the case in the male Corixidæ. Figures illustrating this are shown on plates IX and XXXII of SCIENCE BULLETIN, vol. XI. At that time no observations had been recorded on the mating. The male mounts the female, grasping her with the middle pair of legs, the first pair flexed beneath him, and the abdomen somewhat to the left side. This decided and invariable position to the left is due, of course, to the asymmetrical structure of the male genitalia. The frequency and duration of copulation of various pairs under observation is given herewith.

MATING OBSERVATIONS COVERING 25 DAYS.

DATE	Pair 1.		Pair 2.		Pair 3.		Pair 4.		Pair 5.		Pair 6	
	Obs mating.	Hrs. duration.	Obs. mating.	Hrs. duration.	Obs. mating.	Hrs. duration.	Obs. mating.	Hrs. duration.	Obs. mating.	Hrs. duration.	Obs. mating.	Hrs. duration.
May 15	X	4+	X	4+	X	4+	X	4+	X	4+	X	4+
May 17	X	6+	X	2+	X	4+	X		X	6+		
May 18	X		X2				X		X	1		
May 19	X2	2+	X	2+	X	2+	X2	4+, 2	X	$1\frac{1}{2}$	X	1+
May 20	X	2	X	$2\frac{1}{2}$+			X2				X	6+
May 21	X	$4\frac{1}{2}$+	X	5+			X2		X	$4\frac{1}{2}$+	X	2
May 22	X						X				X	
May 24	X2		X	1	X	$1\frac{1}{4}$	X		X		X2	
May 25	X				X				X			
May 27	X						X		X		X	
May 28	X		X		X				X			
May 29			X						X			
May 31	X								X		X	
June 1	X2		X	7+					X	1+	X	
June 2	X	$3\frac{1}{2}$	X	2+	X	4+	X	2+	X	2+	X	$1\frac{1}{2}$+
June 3	X				X	$6\frac{1}{2}$			X			
June 4			X						X			
June 7	X		X				X		X			
June 9									X		X	

In the table X signifies observed mating. If followed by the figure 2 it indicates two separate matings. The plus sign indicates that the bugs were mating when first or last observed or both.

The above table indicates that the mating clasp may last as long as seven hours, that matings are frequent, often twice a day, and that they occur almost daily over a considerable period of time. Matings were observed in the laboratory from May to November.

OVIPOSITION.

The eggs are either completely or partly buried in the sand, cephalic end uppermost. The partly buried dry egg is white and very difficult to discover in dry sand. When it is moistened it changes to an amber or ferruginous, and with the sand takes on a deeper colored and glistening appearance, which further adds to its resemblance to a sand grain. A photograph of the egg upon a background of sand is shown on plate XIII. The number of eggs deposited by a female during the season must be 200 or more, because 192 nymphs and eggs have been recorded for one female, and it is quite likely that I did

not count the full complement. Oviposition continues throughout the season, the number of eggs laid per day varying from 1 to 13, from 2 to 6 being perhaps the average. A study of the hatching dates on the life-history tables will indicate the rate of egg-laying very well.

INCUBATION.

The incubation period varied from twelve to fifteen days. The red eyespots of the embryo are evident a number of days before hatching. The egg increases in size somewhat as the embryo develops, and the egg becomes darker with development.

HATCHING.

I was fortunate enough to observe the hatching process with the binoculars on several occasions, but never in as satisfactory lighting as I should have liked. The cephalic end of the egg shell splits longitudinally, squarely between the eyes, and extends back above the dorsum of the embryo. Through this rent a white, bulging body appears, resembling the bubble found above the head of *Corixa*. The front part of the head of the embryo pulsates rapidly. By slow straining heaves the embryo crowds out through the opening. Its body is as soft and pliable as a caterpillar. By bulging the fore part of the body and contracting the latter part, it worms its way to freedom—a creamy-white creature marked with two large, dark-red eyes, and with a body nearly cylindrical in shape and the thick limbs all most economically tucked away upon its venter. Then comes the postnatal molt, the casting of the shroud that binds the embryo. Standing erect upon its caudal end, its body encompassed and its limbs tied down by a diaphanous membrane that still holds it helpless to the empty casque in which it was formed, it struggles for freedom. First the membrane gives way above the head and emergence begins. As this skin slips back, the knob-like antennæ, which were directed downward along the beak, are free and change their position. Then the beak appears, and after slowly bending back and forward, one front leg pops out free, then the other. Finally all the legs are free, and the little bug settles down upon them, the shroud still about the tip of the abdomen. He flattens out into a toad bug, and after resting for a time, as if the birth struggles had been most exhausting, he suddenly becomes lively and starts away. Over the first moist pebble he passes, the molt is left, if by chance it did not remain fastened in the slit of the egg-shell. A period of thirty minutes often is consumed in the hatching. One bug that

hatched at 2:35 p. m. was creamy white with dark-red eyes at 3:12 p. m., when a faint pattern began to appear. At 3:35 it was somewhat darker and the pattern more distinct. Thus it takes an hour or so for it to attain its characteristic color.

MOLTING.

An examination of the life-history tables will indicate that mortality at molting time was very great in the rearings. This suggests that conditions were not favorable to normal molting. In the light of R. Takahashi's observations on the Ochteridæ, published in Japanese,* it may be that *Gelastocoris* nymphs, like those of *Ochterus formosanus* Mats., normally fashion for themselves small cells of sand above the ground in which the moltings take place. The sand in the rearing jars was packed, and perhaps too coarse for the nymphs.

The nymph becomes very plump of body along toward the time to change. Several first-instar bugs were under observation during the process of molting. The bug rests upon the sand, all legs outspread and apparently rigid. A longitudinal rent appears on the dorsum of the head and thorax, and the greenish or creamy-white nymph begins bulging out, the dorsal part of the thorax leading. Shortly the head is freed, the slit through the old skin extends back to the abdomen and then laterally to the margins of the body. These lateral fissures enable the bug to work his way out. The new form is so much larger than the old exuvium which encased it, that one wonders how it was ever tucked away in so small a space. When the new instar is entirely free, the old skin may snap back in place again and look like a perfect nymph, save that the eyes are whitish instead of dark red.

The following article appeared in Japanese, by R. Takahashi. The observations are so interesting, and relate to a family so little known, that English-reading students will be glad to give Mr. Takahashi credit for it.

These observations pertain to *Ochterus formosanus* (Mats.), which is not uncommon in Formosa.

1. The adults live upon the sandy shores of ponds and streams, where the colors of their backs merge into their surroundings, rendering them difficult to discover. They are not able to submerge and do not run out upon the water, where they are occasionally found by accident; but the nymphs are amphibious, being often seen submerged.

* R. Takahashi: "Observations on the Ochteridæ," Trans. Nat. Hist. Soc. Formosa, vol. XI, No. 55, pp. 119-125 (1921).

2. The adults are very active, while the nymphs are rather inactive. The death feigning has never been observed.

3. The species is not gregarious, but two or three nymphs are sometimes found in groups.

4. The nymphs sometimes vibrate the abdomen vertically for a few seconds when resting on the shore.

5. The nymphs cover their backs completely with sandy granules. All the nymphal instars have this habit. Their heads are provided on the front with 12 to 14 stout processes projecting forward and arranged in a transverse row, with which they scoop the sand upon the heads and push them backward by the front legs.

6. The nymphs construct for themselves small cells of sand above the ground, using the processes on the front, in which the moltings take place. All the instars have this peculiar habit.

7. The nymphs with the dorsums wettable are amphibious in habit, being often found submerged. When submerged, the bodies are held always just below the surface film, and they swim rather awkwardly, moving all the legs, but do not swim deeper. A store of air for respiration when submerged, is carried with the insect on the lower surface of the abdomen, and the nymphs now and then turn on their backs at the surface, thus exposing the lower surface of the abdomen into free air to take new supply of air. This is done very quickly.

8. The mating habit is almost as in the insects of *Microvelia*, but the males do not remain on the backs of their mates for a long time when the copulation is finished. The males and females mate repeatedly.

9. The eggs are singly placed upon the sandy granules, or upon the decayed leaves on the ground.

10. The egg is similar in shape to that of *Gelastocoris*, species figured by Doctor Hungerford (1919), measuring about 0.7 mm. in length.

11. There are five nymphal instars, as is common for other Heteroptera, and the nymphal stage lasts more than one month.

12. In the adults the front and middle tarsi are two-jointed, and the hind three-jointed, while in the nymphs all the tarsi are always two-jointed.

13. The adults may be seen near Taihoku at almost any time.

NOTES ON REARINGS.

FIRST PAIR.

Rearing Number 4.

This pair consisted of the female that I had kept in the laboratory all winter and a male selected from the spring shipment. They were confined in a six-inch stender in which had been placed a layer of sand with a place scooped out on one side for water. The water, however was taken up by the sand and the entire mass became water-soaked. To make a dry footing for the bugs, a bit of cork was set upright in the soil, but this too became wet. Green algæ covered the sand, the cork, the sides of the jar, and even the bugs were green with it. The surface of the sand was found on July 1

to be teeming with nematodes that were intent upon consuming the fly carcasses supplied as food for the bugs. No careful examination was made of this jar until July 1, when four white eggs were found on top of the cork, placed there in an endeavor, apparently, to keep them out of the wet, soggy sand. I then supplied dry sand to reduce the moisture, and on July 6 found eggs in the sand; observed mating on that date also. July 12 two nymphs hatched. July 20, there were several active first-instar nymphs. July 24, removed 18 dead first-instar forms and observed nine live ones. There were several eggs yet to hatch and some fresh eggs. July 27, removed two second-instar forms and took out 18 dead first-instar bugs. Seven live ones were observed at this time. July 30, observed a couple hatch and counted 10 active first-instar nymphs; also removed 7 dead ones. On August 1 there were nine live first-stage forms; removed 2 dead ones. August 2, counted 11 live first-stage bugs and removed 6 dead ones. On the 3d removed 2 dead ones. On the 4th there were 3 newly hatched bugs, and I removed 5 dead ones. On August 5 one first-instar bug was observed feeding upon another. August 7 there were at least 18 nymphs, three of them white, denoting recent hatching. August 8, 7 dead firsts were removed, but a dozen were still lively. August 9 another freshly emerged nymph was noted, and on the 10th 2 more. August 13, removed a second-instar form, and on August 15 another newly hatched was noted. August 16, a dark nymph was caught in the act of killing a white newly emerged brother. He was upon the back of his victim with beak inserted just back of the unfortunate's head. The latter was struggling, but to no avail. On August 18 one second-instar form was isolated and 34 dead first-stage bugs removed. Mr. Hoffman found three nymphs feeding upon their fellows, and all three victims were alive and kicking. There were about a dozen live bugs of this stage. August 21 brought forth 3 second-stage bugs, which were taken out. August 22, 11 dead firsts were moved, and on the 23d 3 dead firsts and 1 live second removed. August 24, 2 dead firsts were taken out. August 29, 5 dead first were removed, and on August 31 the female was found dead. Twenty-three dead nymphs were counted out and 8 eggs transferred to another stender. No live nymphs were present, and the jar was set aside till September 20, when a careful count was made of remains—10 eggs and 16 nymphs completed the record for this pair. The above notes have been given to show the result of trying to rear the bugs together.

This pair of bugs was observed mating May 15, 17, 18, 19, 20, 21, 22, 24, 27, June 2, 7, 22, and July 6. No count of eggs laid was attempted, but 22 eggs, 160 first-instar and 10 second-instar nymphs were taken, a total progeny of 192, with egg-lay noted from July 1 to last of August—this the performance of a female that spent the preceding winter in the laboratory.

REARING RECORD OF NO. 4.

No.	Date hatched	1st molt.	2d molt	3d molt	4th molt.	5th molt.	Sex.	Days in stages. 1st.	2d	3d	4th.	5th.	Tot.	Adult died.
4a	July 12	July 21	Aug 2	Aug 15	Aug 30	Sept 19	♂	9	12	13	15	20	69	Oct. 6
4b	July 12	July 20	Died July 24					8	4°					
4c	July 16	July 24	Aug 13	Died Aug 16				8	20	3°				
4d	July 16	July 25	Aug. 5	Aug 16	Aug 31	Sept 23	♂	9	11	11	15	24	70	Nov 17
4e	Aug 1	Aug 13	Died Aug 31					12	18°					
4f	Aug. 8	Aug. 18	Died Aug 31					10	13°					
4g		Aug. 20	Sept 10	Died Sept. 14					21	4°				
4h		Aug 21	Sept 11	Sept 20	Oct 5	Died Oct. 20			21	9	16	15°	71?	
4i		Aug 21	Sept 6	Sept 17	Sept 27	Oct. 26	♂		16	11	10	29	76?	Oct 28
4j		Aug. 23	Died Sept. 24						1°					

° indicates "died" in this and following tables.

SECOND PAIR—OFFSPRING IN FOUR SERIES.

Rearing Number 1, Series m.

On July 6, Mrs. Wiley brought me 7 bugs from Chanute, which she had captured July 3. One pair, observed mating, I placed in a small stender on sand with a sprig of moss. July 8, quite a number of eggs were in the sand, so the adults were removed to another stender. On July 15, the eggs showed pink eyespots of the embryo within; and on July 19, 8 hatched and were isolated for rearing. July 21, 5 more hatched; and July 24, 3 more. Thus at least 16 eggs were laid by this female in two days, and the incubation period was 12 or 13 days. The rearing table marked 1m series is a record of fifteen of these nymphs.

Rearing Number 1, Series n.

The pair was transferred from 1m to this stender, containing sand, on July 8; observed mating on the 11th and removed on the 12th. Could find no eggs, and though this stender was studied till July 29, no nymphs appeared.

Rearing Number 1, Series o.

Transferred the pair from number 1n to this stender, containing sand, July 12. On July 24, 4 nymphs hatched, and so I removed the adults to another stender and transferred the nymphs to jars as they hatched. The rearing table marked 1o series indicates the dates of hatching. But to this list of 49 must be added the following: July 27, 6 first instars in large stender, labeled 10h. August 6, 4 dead instars; and August 8, 2 more. A total, therefore, of 61 hatched from eggs deposited between July 12 and 24, an average of 5 per day, with a record of 13 for August 6. Incubation period, 12 days.

Pair Number 1p.

This pair of adults was transferred from 1o on July 24. They were observed mating on this date and again on August 8, when 2 first-instar forms hatched. Removed the male on August 10 and returned on the 18th. This female was caught twice feeding upon her own offspring. Besides the 65 nymphs hatched from August 8 to September 27 and used in rearings, 28 dead ones were taken out of this stender in which the pair was confined—a total of 93 offspring between July 24 and September 27. The observed matings were on July 24, August 8, August 21 and September 20. One adult died October 4 and the other October 23. The rearing data are presented on that portion of the table marked IP series.

Summing up for this pair of bugs taken from the wild on July 3 and entered for observation on July 6, we get a total progeny of 170 hatched, and of this number we were able to rear to the adult stage 4 insects.

SECOND PAIR, REARING TABLE.

Series 1m.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages.						Adult died.
								1st.	2d.	3d.	4th.	5th.	Tot.	
1ma	July 19	Died Aug. 14						26°						
1mb	July 19	Died Aug. 7						19°						
1mc	July 19	Aug. 11	Oct. 7	Died Oct. 25				23	27	19°				
1md	July 19	Aug. 6	Died Aug 12					18	6°					
1me	July 19	Died Aug. 5						17°						
1mf	July 19	Died Aug. 9						21°						
1mg	July 19	Died July 28						9°						
1mh	July 21	Aug. 1	Aug. 11	Died Aug. 16				11	10	5°				
1mi	July 21	July 28	Aug. 11	Died Aug. 16				7	14	5°				
1mj	July 21	Aug. 7	Died Aug 11					17	4°					
1mk	July 21	Died Sept. 12						53°						
1ml	July 21	Died July 30						9°						
1mm	July 21	July 25	Aug. 6	Aug. 15	Aug. 30	Sept. 19	♂	4	12	9	15	20	60	Nov. 4
1mn	July 24	Aug. 9	Died Aug. 10					16	1°					
1mo	July 24	Died July 30						6°						

Series 1o.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages. 1st.	2d.	3d.	4th.	5th.	Tot.	Adult died.
1oa	July 24	Aug. 11	Died Aug. 14					18	2°					
1ob	July 24	Aug. 10	Died Aug. 13					17	3°					
1oc	July 24	Died July 30						6°						
1od	July 24	Died July 31						7°						
1oe	July 25	Died Aug 10						16°						
1of	July 25	Aug. 12	Sept 2	Sept. 17	Died Oct. 1			18	21	15	13°			
1og	July 25	Aug. 10	Died Aug. 14					16	4°					
1oi	July 29	Died Aug 8						10°						
1oj	July 29	Died Aug. 5						7°						
1ok	July 29	Aug. 13	Aug. 31	Sept. 13	Sept. 25	Oct 21	♀	15	18	13	12	26	84	Dec. 20
1ol	July 29	escaped												
1om	July 29	Died Aug. 11						13°						
1on	July 29	Died Aug 5						7°						
1oo	July 29	Died Aug. 10						12°						
1op	July 30	Died Aug. 7						8°						
1oq	July 30	Aug. 13	Sept. 15	Died Sept. 24				14	33	9°				
1or	July 30	Died Aug. 1						2°						
1os	July 30	Aug. 11	Aug. 28	Sept 12	Sept. 24	Died Oct. 22		12	17	15	12	29	85	
1ot	July 30	Died Aug. 28						29°						
1ou	July 30	Died Aug. 8						9°						
1ov	July 30	Died Aug. 8						9°						
1ox	July 30	Died Aug. 9						10°						
1oy	July 30	Died Aug. 8						9°						
1oaa	Aug. 1	Died Aug. 9						8°						

Series 1o.—Concluded.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages. 1st.	2d.	3d.	4th.	5th.	Tot.	Adult died.
1obb	Aug. 1	Aug. 18	Died Sept. 17					17	30°					
1occ	Aug. 1	Died Aug. 8						7°						
1odd	Aug. 2	Died Aug. 10						8°						
1oee	Aug. 2	Died Aug. 9						7°						
1off	Aug. 2	Died Aug. 9						7°						
1ogg	Aug. 2	Died Aug. 9						7°						
1ohh	Aug. 2	Died Aug. 9						7°						
1oii	Aug. 2	Died Aug. 9						7°						
1ojj	Aug. 2	Died Aug. 9						7°						
1okk	Aug. 4	Died Aug. 10						6°						
1oll	Aug. 4	Died Aug. 14						10°						
1omm	Aug. 4	Died Aug. 9						5°						
1onn	Aug. 4	Died Aug. 9						5°						
1ooo	Aug. 5	Died Aug. 10						5°						
1opp	Aug. 5	Died Aug. 15						10°						
1oqq	Aug. 5	Sept. 12	Sept. 26	Oct. 21	Died Nov. 17			38	14°	25	27°			
1orr	Aug. 6	Died Aug. 11						5°						
1oss	Aug. 6	Died Aug. 10						4°						
1ott	Aug. 6	Died Aug. 13						7°						
1ouu	Aug. 6	Died Aug. 9						3°						
1ovv	Aug. 6	Died Aug. 12						6°						
1oww	Aug. 6	Died Aug. 14						8°						
1ozz	Aug. 6	Died Aug. 10						4°						
1oaaa	Aug. 6	Died Aug. 13						7°						
1obbb	Aug. 6	Died Aug. 11						5°						

Series 1p.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages. 1st.	2d.	3d.	4th.	5th.	Tot.	Adult died.
1pa	Aug. 8	Died Aug. 14						6°						
1pb	Aug. 8	Died Aug. 14						6°						
1pc	Aug. 9	Died Aug. 14						5°						
1pd	Aug. 9	Died Aug. 15						6°						
1pe	Aug. 9	Sept. 22	Died Oct. 15					44	23°					
1pf	Aug. 10	Died Aug. 18						8°						
1pg	Aug. 10	Died Aug. 16						6°						
1ph	Aug. 10	Died Aug. 19						9°						
1pi	Aug. 10	Died Aug. 19						9°						
1pj	Aug. 10	Died Aug. 17						7°						
1pk	Aug. 11	Died Aug. 12						1°						
1pl	Aug. 12	Died Aug. 25						13°						
1pm	Aug. 16	Died Aug. 22						6°						
1pn	Aug. 16	Died Aug. 22						6°						
1po	Aug. 16	Died Aug. 24						8°						
1pp	Aug. 16	Died Sept. 9						24°						
1pq	Aug. 16	Died Aug. 23						7°						
1pr	Aug. 16	Died Sept. 2						17°						
1ps	Aug. 17	Died Aug. 26						9°						
1pt	Aug. 17	Died Aug. 29						12°						
1pv	Aug. 18	Sept. 13	Died Oct. 6					26	23°					
1pw	Aug. 19	Died Aug. 1						13°						
1px	Aug. 21	Died Aug. 2						12°						
1py	Aug. 21	Sept. 9	Sept. 23	Oct. 11	Died Oct. 23			19	14	18	12°			

Series 1p—Continued.

No.	Date hatched	1st molt.	2d molt.	3d molt	4th molt	5th molt.	Sex	Days in stages. 1st.	2d	3d	4th.	5th	Tot.	Adult died.
1pz	Aug 22	Died Aug. 11						20°						
1paa	Aug. 23	Died Aug 4						12°						
1pbb	Aug. 25	Died Aug. 16						22°						
1pcc	Aug 26	Died Aug. 29						3°						
1pdd	Aug. 27	Died Sept. 4						8°						
1pee	Aug 28	Sept. 13	Died Sept 24					16	11°					
1pff	Aug 29	Sept. 15	Sept 25	Oct 14	Nov 17	Died Nov 26		17	10	20	34	9°		
1phh	Aug 30	Died Sept 9						10°						
1pii	Sept 3	Died Sept 17						14°						
1pjj	Sept 4	Died Sept 24						20°						
1pkk	Sept 4	Died Sept 15						11°						
1pll	Sept 7	Died Sept. 9						2°						
1pmm	Sept. 7	Died Sept 15						8°						
1pnn	Sept 9	Sept 21	Oct 15	Nov. 4	Died Dec 4			12	24	20	30°			
1poo	Sept 9	Died Sept. 18						9°						
1ppp	Sept 9	Died Sept. 17						8°						
1pqq	Sept. 9	Died Sept 19						10°						
1prr	Sept. 10	Died Sept. 21						11°						
1pss	Sept 12	Died Sept. 22						10°						
1ptt	Sept. 12	Died Sept. 26						14°						
1puu	Sept. 12	Died Sept. 21						9°						
1pvv	Sept. 12	Died Sept. 28						16°						
1pww	Sept. 12	Oct. 8	Died Oct. 12					26	4°					
1pxx	Sept. 12	Sept. 23	Oct 11	Died Nov 13				11	18	33°				

Series 1p—Concluded.

No.	Date hatched.	1st molt.	2d molt	3d molt.	4th molt.	5th molt.	Sex.	Days in stages.						Adult died.
								1st	2d.	3d.	4th.	5th.	Tot.	
1pyy	Sept. 13	Died Sept. 23						10°						
1pzz	Sept 13	Died Sept. 21						8°						
1paaa	Sept 13	Sept. 29	Died Nov. 2					16	3°					
1pbbb	Sept. 13	Died Sept. 28						15°						
1pccc	Sept. 15	Oct 5	Nov 2	Died Dec. 30				20	28	59°				
1pddd	Sept 15	Died Sept 25						10°						
1peee	Sept 15	Sept. 27	Died Oct. 15					12	18°					
1pfff	Sept. 17	Died Sept. 30						13°						
1pggg	Sept. 17	Died Sept. 25						8°						
1phhh	Sept 17	Died Sept 19						2°						
1piii	Sept 22	Died Oct. 2						10°						
1pjjj	Sept. 22	Died Sept 28						6°						
1pkkk	Sept. 23	Died ?						?						
1plll	Sept 23	Died Oct. 13						20°						
1pmmm	Sept 23	Oct. 18	Died Oct. 30					25	12°					
1pnnn	Sept. 25	Died Sept 29						4°						
1pooo	Sept. 27	Died Oct. 1						4°						

It was not planned when I began the studies to carry the rearings to such an extent and therefore the simple system of designating became cumbersome.

THIRD PAIR.

On May 14 I placed a pair in a small stender on the sand. Eggs showed eyespots June 2. June 10, 4 nymphs appeared, and on this date adult female died. The rearings from this pair are given in the following table:

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt	5th molt.	Sex	Days in stages.						Adult died.
								1st.	2d.	3d	4th.	5th	Tot	
1b	June 10	June 28	Died July 17					18	19°					
1c	June 10	June 19	July 1	Escaped July 6				9	12					
1d	June 13	Died June 28						15°						
1e	June 13	Died June 21						8°						
1f	June 14	June 24	July 3	July 11	July 19	Aug. 2	♀	10	9	8	8	12	47	Jan. 11, 1921
1h	June 17	June 28	Died June 28					11°						
1i	June 17	July 1	Died July 6					14	5°					
1j	June 21	Died July 2						11°						
1k	June 21	June 28	July 6	July 15	July 22	Aug. 7	♀	7	8	9	7	16	47	Nov. 2
1l	June 22	July 5	July 15	July 23	Aug 6	Aug. 31	♀	13	10	8	14	25	70	Oct. 10

FOURTH PAIR.

In a large stender containing sandy loam, and labeled No. 7, was placed a mating pair of bugs, June 28. Eggs were discovered in the soil on July 8. July 13 nymphs hatched and the adults were removed. July 20, 7 more nymphs were out. These 12 nymphs were isolated in stenders and a tabular report of these follows. The incubation period was somewhere between 7 and 15 days.

No.	Date hatched.	1st molt	2d molt.	3d molt	4th molt	5th molt.	Sex	Days in stages.						Adult died.
								1st.	2d.	3d	4th.	5th.	Tot.	
7a	July 13	Escaped												
7b	July 13	July 20	Died July 23					7	3°					
7c	July 14	July 21	Aug. 6	Died Aug 14				7	16	8°				
7e	July 14	Died July 23						9°						
7f	July 20	Died July 30						10°						
7g	July 20	July 28	Aug 6	Aug 16	Sept 1	Sept 21	♀	8	9	10	16	20	63	Oct 28
7h	July 20	Aug. 16	Aug 30	Sept 12	Sept 22	Oct 17	♂	27	14	13	10	25	89	Nov 14
7i	July 20	Aug 4	Aug 14	Aug 26	Sept 11	Sept 29	♂	15	10	12	16	18	71	Nov 21
7j	July 20	Aug. 9	Died Aug 12					20	3°					
7k	July 20	Died July 28						8°						
7l	July 31	Aug. 6	Aug. 16	Sept 14	Died Sept 27			6	17	29	13°			

FIFTH SERIES.

A sprig of moss and earth containing eggs were placed in a stender July 12. These eggs were deposited by bugs sent me July 6, amongst the material in which they were packed. They began hatching July 20 and finished July 24. The record of the eight nymphs isolated is shown in tabular form below.

No.	Date hatched	1st molt.	2d molt	3d molt.	4th molt.	5th molt.	Sex.	Days in stages. 1st.	2d	3d	4th.	5th	Tot	Adult died.
9a	July 20	July 30	Aug 19	Sept 15	Oct. 7	Died Oct 18		10	20	27	22	11		
9b	July 20	Aug. 6	Aug 18	Aug. 30	Sept. 13	Oct 5	♂	17	12	12	14	22	77	Oct 17
9c	July 21	Aug 2	Died Aug. 10					12	8					
9d	July 21	Died July 31						10						
9e	July 24	Died Aug 9						16						
9f	July 24	Died Aug 3						10						
9g	July 24	Aug 1	Died Aug 9					8	8					
9h	July 24	July 30	Aug 15	Sept 9	Sept 22	Died Oct 14		6	16	25	13	22		

SIXTH PAIR.

Placed 2 female bugs in large stender marked No. 12, on July 20. These bugs were from those Mrs. Wiley collected July 3. On August 2, 2 nymphs appeared—an incubation period of 13 days. The nymphs continued to appear, and their record is shown in table 12 below. September 5 only 1 adult was to be found, and yet it was impossible for the bugs to escape from the jar. September 6 both were gone from view, but later they were again above the sand. In cloudy, threatening weather, the toad bugs bury themselves beneath the surface and appear again in sunny weather.

Table 12.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt	Sex	Days in stages. 1st.	2d	3d.	4th.	5th	Tot.	Adult died.
12a	Aug 2	Died Aug. 8						6						
12b	Aug. 2	Died Aug. 9						7						
12c	Aug. 8	Died Aug. 14						6						
12d	Aug 9	Died Aug 14						5						
12e	Aug 10	Died Aug 12						2						
12f	Aug. 10	Aug. 26	Died Sept. 17					16	22					
12g	Aug. 11	Died Aug. 19						8						
12h	Aug. 15	Died Aug. 21						6						
12i	Aug. 15	Died Aug. 22						7						
12j	Aug. 16	Died Aug. 28						12						

SEVENTH PAIR.

In stender marked 2a, placed a mating pair on May 25. On June 3, found an egg imbedded in the sand for about one-half of its length. On June 13, found 11 eggs, 5 or 6 of which showed pink eyespots, so removed the adults to another stender. The eggs began hatching June 17 and continued until June 28. The minimum incubation period for some of the eggs was 15 days.

EIGHTH PAIR.

Pair from Chanute placed in stender labeled 1a, June 2. The female died June 10. Eggs hatched June 24 and June 28. Incubation period at least 14 days, likely longer.

NINTH PAIR.

Female emerged from one of the rearings (1l) on August 31, from a nymph that hatched June 22. Added a male, but no mating observed, and female died October 10.

TENTH PAIR.

Female emerged from one of the rearings (1k) on August 10, from nymph that hatched June 21. Placed a male with her and matings were observed on August 13, 15 and 18. No eggs were found after most thorough search. Female died November 4.

DESCRIPTION OF STAGES.

(See plates XIII and XIV.)

THE EGG.

Size Length, 1.25 mm.; diameter, .91 mm.

Shape. Broadly oval. The surface is roughly granular and marked into regular hexagonal areas by thickened ridges of the chorion

FIRST-INSTAR NYMPH.

Size. Length, 2 mm.; width of thorax, 1.4 mm.; width of head, 1.2 mm.

Color. Eyes dark; body mottled to checkered obscurely, general color sometimes light, sometimes dark. Legs and abdomen are usually marked as described for later instars.

Structural peculiarities. Eyes larger relatively than in succeeding instars. They are not placed upon as high elevations and the inner emarginations are not marked. The beak is four-segmented; the antennæ three-segmented; and the tarsi appear one-segmented, terminating in two claws. The middle and hind tarsi, however, have a short basal segment, making two. Lateral margin of mesothorax less in length than that of metathorax.

SECOND-INSTAR NYMPH.

Size. Length, 2.5 mm.; width of thorax, 1.9 mm.; width of head, 1.5 mm.

Color. Eyes still dark, not distinctly banded. Pattern obscured, that of limbs and abdomen as in later instars.

Structural peculiarities. The inner emargination of the eyes a little more marked than in the preceding instar. Lateral margin of mesothorax equal in length to that of metathorax.

THIRD-INSTAR NYMPH.

Size. Length, 3.5 mm.; width of thorax, 2.7 mm.; width of head, 2.0 mm.

Color. The eyes faintly banded with three bars of color, one of them on the inner margins. The general pattern variable; but when defined, like other instars.

Structural peculiarities. The inner emargination of the eye now regular and marked. Ocelli faintly visible in some, while in others unmistakably present. Lateral margin of Mesothorax now a little longer than that of metathorax.

FOURTH INSTAR NYMPH.

Size. Length, 4.5 mm ; width of thorax, 3.6 mm., width of head, 2.4 mm.

Color. The general pattern as in fifth. The eyes banded by four faint bars, one of which is on inner margin.

Structural peculiarities. The lateral margin of mesothorax now is about twice as long as that of the metathoracic margin, due, of course, to the lengthening of the wing pads. The body is covered with closely set short, stout, appressed spines, which show more plainly than in the preceding instar. The ocelli show plainly now. They are located just above the lateral arms of what I take to be the epicranial suture. The nymphal exuvium always shows a Y-shaped rent on the head, and it is on the upper margin of the lateral arms of this fissure that the ocelli are located

FIFTH INSTAR NYMPH.

Size. Length, 6.2 mm.; width of thorax, 5.0 mm.; width of head, 3.0 mm

Color. Color variable from very light to very dark, and the pattern varying from obscure to distinct. The eyes have five dark bars. There are two pairs of black dots on the face, one above the other, and laterad and below the ocelli. A median black dot on vertex. The pronotum has front two-thirds of lateral margins of prothorax darker There is a pair of black spots caudo-laterally of each pronotal elevation, of which there are two. The mesonotum has two rectangular black spots on front margin either side of median line. There is a transverse row of four black dots across caudal third of mesonotum; wing pad has a dark rectangular spot on shoulder; the middle of the pad crossed by another dark area; tip and inner margin of pad dark. Two faint dark irregular spots in the outer third of wing pad gives a mottled effect to the whole. A white spot is found on second abdominal segment either side of median line. A row of dark marginal spots, roughly triangular, cover the front two-thirds of the margin of each abdominal segment. There are also two rows of dark submarginal spots, faint and ill defined. The legs are banded with dark bands. The hind tibiæ have three dark bands besides being dark at the ends.

Structural peculiarities. The wing pads of the mesothorax now extend almost to caudal margin of thorax, nearly obscuring lateral margin of metathorax.

SUMMARY.

The toad bug places its eggs in the sand. The eggs hatch in about 12 days. There are five nymphal instars. Forty-nine first-instar bugs transformed in an average of 15 days (the shortest time 4 days and the longest 44 days). Thirty-three second-instar bugs transformed in an average of 16 days (shortest time 8 days and longest 33 days). Twenty-two third-instar bugs averaged 15 days (the shortest time 8 days and the longest period, not counted in the average because it failed to molt, was 59 days). Eighteen fourth-instar forms averaged 15½ days (minimum 7 days and maximum 34 days). Thirteen fifth-instar forms averaged 22 days (minimum 12 and maximum 29 days). The average number of days for the thirteen adults to develop from the hatching to emergence was 70½ days. The shortest period was 47 days and the longest 89 days. By adding the 12 days incubation of the egg, we get a total development period of from 60 to 100 days. The adult female may deposit a dozen eggs a day, but would average perhaps only 2 to 6 over the period of two or more months. One hundred and ninety-two eggs and nymphs were counted from one female from July 6 to September 27. The nymphs possess ocelli, plainly distinguished as early as the third instar. All the stages are predaceous and much like their parents in other habits as well.

PLATE XIII

Gelastocoris oculatus Fabr

FIG 1 Adult bug (not *oculatus*, but an undescribed species in western Kansas) upon sand, showing how its mottled pattern makes it difficult to discern

FIG. 2 Ventral view of above species of bug Enlarged photograph showing the bug clasping three lace bugs

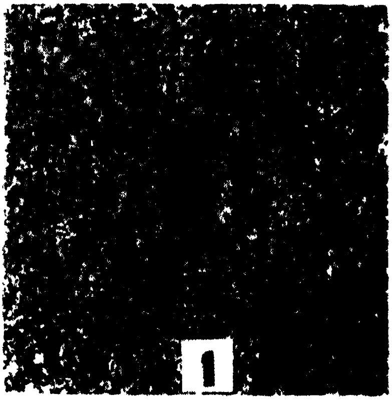
FIG 3 First-instar nymph *Gelastocoris oculatus* Fabr Enlarged dorsal view, same species shown in figures 1 and 2

FIG 4 Another toad bug Enlarged ventral view, showing bug with prey

FIG 5 First-instar nymph, *Gelastocoris oculatus* Fabr, ventral view

FIG 6 Microphotograph of egg and first-instar nymph Nymph in center of picture and the white oval egg to the right of it The egg resembles the sand grains very closely

PLATE XIII.



1

2

3

4

5

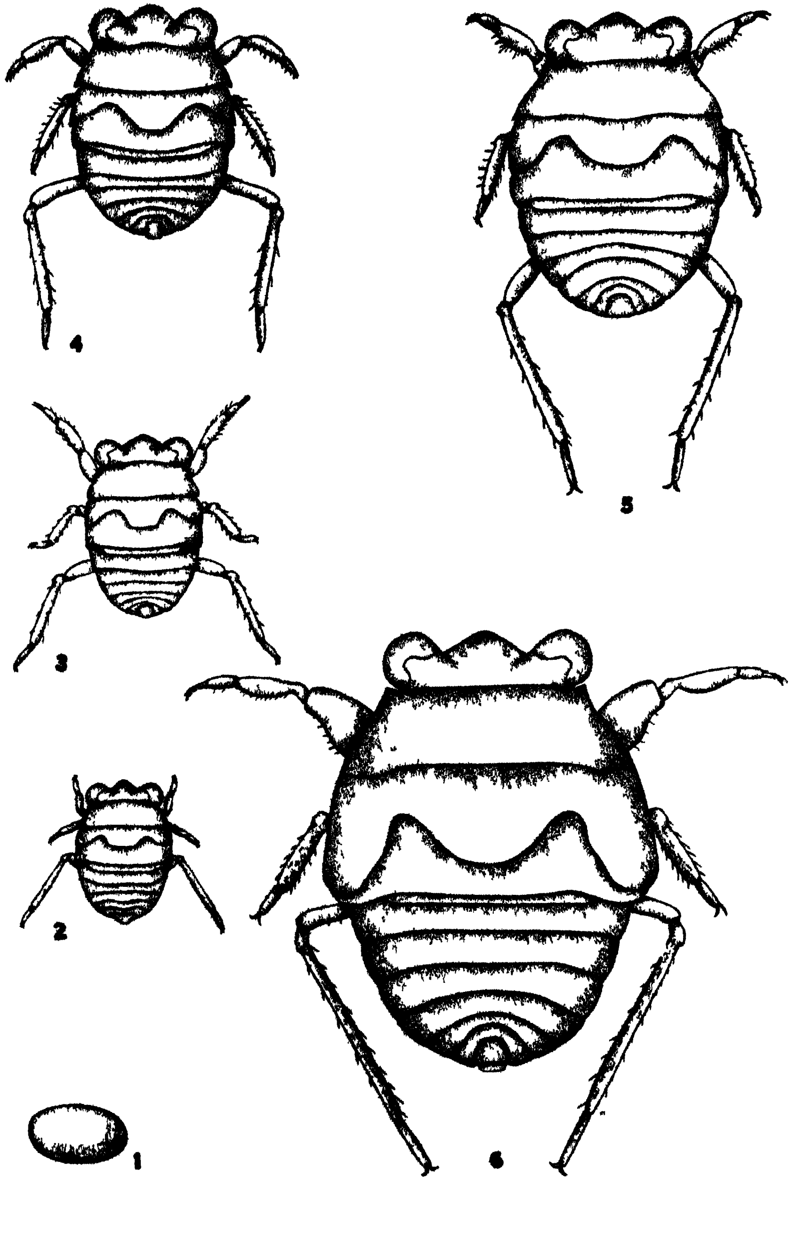
9

PLATE XIV.

Gelastocoris oculatus Fabr.

FIG. 1. Egg.
FIG. 2 First-instar nymph
FIG. 3. Second-instar nymph.
FIG. 4 Third-instar nymph
FIG. 5. Fourth-instar nymph
FIG. 6. Fifth-instar nymph.

PLATE XIV.



THE

KANSAS UNIVERSITY SCIENCE BULLETIN

VOL. XIV, No. 6—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 6.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 6.

A New Subterranean Isopod from Kansas.

Cæcidotea tridentata (Crustacea).

By H. B. HUNGERFORD,
Professor of Entomology, University of Kansas

IN MARCH of 1919, Mr. William Hoffmann, field assistant in our department of entomology at the University of Kansas, brought to me for determination some specimens of an isopod which he had taken from a cistern in Lawrence, Kan.

They prove to belong to a new species of the genus *Cæcidotea*. For them I propose the name *Cæcidotea tridentata*, because the propodus of the first pair of legs of the male is armed with three conspicuous processes, a character which separates them from the previously described species.

The crustacean genus *Cæcidotea* Pack., as the name implies, is characterized by the absence of eyes, by the fact that the terminal s gment of the body is much longer than broad, and by the elongate, narrow body. An analytical key to the genus was given by Harriet Richardson in her monograph of the isopods of North America, in 1905. There were known at that time four species, namely, *C. stygia* Pack., *C. nickajackensis* Pack., *C. richardsonæ* Hay and *C. smithsii* Ulrich. Doctor Ortmann, 1918, in chapter XXV of "Fresh-water Biology," had Miss Richardson's work in mind when he said there were four species of the genus and that they are found in caves, springs issuing from caves, and artesian wells. However, in 1911, in the Pomona College *Journal of Entomology*, volume 3, No. 3, Blanche Stafford described a fifth species, namely, *Cæcidotea alabamensis*, from a well in Auburn, Ala.

The following table will serve to separate the six species of the genus now known:

A. Propodus of first pair of legs armed with one or more triangular processes.

B. Propodus of first pair of legs armed with a triangular process near the distal end and with a long spine at the proximal extremity. Uropods about one-half the length of terminal abdominal segment. Outer branch three-fourths as long as inner, which equals the peduncle in length. *C. nickajackensis* Pack.

BB Propodus of first pair of legs armed with two triangular processes.

C. Propodus with three additional short processes. Uropods about as long as terminal abdominal segment. Outer branch two-thirds as long as inner, which is two-thirds as long as peduncle *C. stygia* Pack.

CC. Propodus with three additional spines not processes. Uropods a little longer than terminal abdominal segment. Outer branch about one-half as long as inner, which is two-thirds as long as peduncle. *C. alabamensis* Stafford.

BBB. Propodus of first pair of legs armed with three triangular processes. *C. tridentata*, sp. nov.

AA. Propodus of first pair of legs not armed with triangular processes, but edged inside with spines.

B First pair of antennæ, with flagellum composed of eleven articles, extend one-third the length of the fifth article of the peduncle of the second antenna. Second antenna longer than the body; flagellum composed of about eighty-six articles. *C. richardsonæ* Hay.

BB First pair of antennæ, with flagellum composed of five articles, extend half the length of the peduncle of the second antenna. Second pair of antennæ "probably as long as body," flagellum composed of "at least forty segments" *C. smithsii* Ulrich.

Cæcidotea tridentata sp. nov.

(Plate XV)

Size. The body without the antennæ and uropoda measures in length from 9 mm. to 19 mm. and in width from 1¾ mm to 3 mm The length of the body is approximately five or six times the width. This species is much larger than the others of this genus that have been described From the descriptions I infer that 10 mm. is about the maximum of *C. stygia* Packard, the largest member of the genus, while 3 mm is supposed to be the maximum of *C. smithsii* Ulrich, the smallest These figures suggest that the smallest mature *C. tridentata* are about the size of some of the members of other species, but the largest individuals are fully double that size.

Color. The color is chalky white, the body wall being sufficiently clear to show the dark food canal within. Material stored in alcohol appears very pale yellowish gray.

Structure. Head: Narrower than first thoracic segment. Wider than long The cephalic margin narrower than the caudal, somewhat concave, and bearing the antennules and antennæ, the bases of the latter appearing very heavy when compared with the size of the head The antennule consists of the basal segments and a flagellum of from twelve to eighteen segments, the two parts of about equal length; the basal segment stoutest, a trifle longer than twice its width; second segment two-thirds as broad as basal and about same length; third segment much smaller; five-eighths as broad and one-half as long as second. Its distal end bears the tapering flagellum. The an-

tennæ are relatively large and consist of a basal part of six segments and a flagellum of from sixty to eighty segments. Each of the first four segments of the basal part is broader than long. Taken together they are equal in length to the fifth segment, which is a little shorter than the sixth, from which arises the many-segmented flagellum. The mandible bears a large three-segmented flattened palp and two chitin-tipped processes, one a chisel-like cutting edge and the other bearing from four to seven teeth.

Thorax: The segments of the thorax are loosely articulated and their lateral margins are fringed with very short, stout setæ. All are broader than long. It bears seven pairs of legs, of which the first pair is subchelate.

The first pair of legs is shorter than the others. In the males the propodus is very large and bears three well-developed processes, one at the base and two near the distal end. The basal one is bifurcate in some and in others bears instead a strong seta. There are seven divisions to each limb, counting the clawlike terminal one. The propodus is the enlarged fifth division by this count. The limbs bear many strong setæ and increase in length from the first to the last.

Abdomen: The first two segments of the abdomen are short. The so-called third is nearly twice as long as wide and carries the uropods, each of which consists of a basal part and two terminal branches. The uropods are longer than the abdominal segment which bears them, the relative length being 5:3. The basal segment is nearly as long as the last abdominal segment, the ratio about 6:7 in the males. The two branches are of very unequal length; the one female possessing uropods had this basal segment 1:3, the inner being much the larger. The relative lengths vary from 3:2 in the female to 4:1 in the male. The inner branch is to the peduncle as 3:4. There is considerable variation in the comparative lengths of these parts. The second pleopod of the male, the first of the female and the third pleopods of both sexes are unlike those figured by Stafford for *C. alabamensis*.

Holotype, allotype and paratypes in alcohol. Kansas University collection

The females are smaller than the males and do not have as well-developed propodi. The sexual dimorphism appears not to have been recorded in the genus heretofore. Another point not mentioned in descriptions is the fact that the females possess the flattened brood pouches or oöstegites at the base of the first four pairs of legs. Our specimens were obtained in June, and some of the females bear these plates.

I asked Mr. Hoffmann, who gathered the material, to submit a few notes relating the circumstances of their collection. His notes in substance follow:

The cistern from which these specimens were taken is about eight feet in diameter and nine feet deep. It contains a square brick filter, resting on the bottom in the center, which measures three or four feet square at base and tapers to its top, some four feet above, where it is just large enough for a four-inch casing, which extends

above to within three feet of the top. This casing surrounds the pipe leading to the pump, and is open at the top. The water supplying the cistern is caught upon the roof of the house and conducted to the cistern by galvanized pipes three or four inches in diameter.

On one occasion during a rain two isopods were observed by the lady of the house to be washed out of the elbow pipe leading from the gutter along the eaves of the house onto the sloping tin roof of the kitchen, thence into another gutter and down the pipe to the cistern. She concluded, therefore, that these animals, which she pumped up by way of the pitcher pump in the kitchen sink, were either "rained or had bred in the collection of wet leaves in the gutters of the house or in the elbow of the pipe leading from them."

A number of specimens were taken alive in the water pumped from the cistern. One of these was placed in a specimen jar, three and one-half inches in diameter and three inches deep, where it lived in one and one-half inches of water from June 18 until July 26. The water was replenished from time to time with dirty pond water, containing many small organisms.

Most of the specimens died within a few days. When several were placed together they seemed to take no notice of each other. The pleopods were observed to be in vibration as an individual made its way through the water.

It is unfortunate that we were too busy to run any behavior experiments upon these most interesting forms.

NOTE.—Through the kindness of the custodian of Crustacea I had the privilege of examining the *Cæcidotea* material in the National Museum at Washington, D. C. One jar marked *Cæcidotea stygia* contains eight vials; four of these contain large specimens which belong to the species I have described as new. It is interesting to note that they were collected at Topeka, Kan. They bear labels as follows: "Gift of E. A. Popenoe, Topeka, Kansas," and were taken "April 9, May 4, May 12, May 29, 1912." The other four vials contain material taken from "Graham's Spring, Lexington, Va., 1876"; Richardson's Spring, Ky., W. P. Hay, Col."; "Irvington, Ind., from wells W. P. Hay"; "Mammoth Cave, Ky., R. E. Call."

The last four lots are much smaller specimens than the Kansas material. The material from Virginia, Richardson's Spring, Ky., and from Indiana, differs materially from the Kansas species. The species is broader than the Kansas crustacean, and the third pleopods are not only much broader comparatively, but are more truncate at the tip.

THE

KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV, No. 7—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 7.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

TABLE OF CONTENTS.

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 7.

Studies on *Cicadella hieroglyphica* Say (Homoptera, Cicadellidæ.)

BY LUCY M HACKMAN.

Submitted to the department of entomology and to the graduate faculty of the University of Kansas in partial fulfillment of the requirements for the degree of master of arts, May 15, 1922

INTRODUCTION.

THE following notes on the life history of *Cicadella hieroglyphica* consist of observations made from specimens in the field and in the laboratory. A growth of young willows along the Kansas river offered a splendid opportunity for the former, for there *Cicadella hieroglyphica* may be found at all seasons in very large numbers. The laboratory observations were made from specimens collected at this place and reared on willow in the laboratory. The most satisfactory results were obtained when the willow was planted in large glass rearing cages. The leaf hoppers could move about at will and were easily observed.

Only a general description of the abdomen is given, for the chief concern of this paper is the genitalia. In tracing out the development of the genitalia in the male and female, the adult genitalia were used as a starting point. To trace the development, the various changes in the genitalia from one instar to another were studied. A study of the ventral surface of the eighth and ninth abdominal segments was sufficient in the case of the female, for all three genital appendages are readily seen from a ventral view. But in the case of the male, where the two pairs of appendages are dorsal in position only, the development of the ventral ones could be traced by such a study. Therefore, particular attention was given to these dorsal or internal genitalia. For this purpose the pygofers were split open

along their dorsal surface, the overlying integument carefully removed, and the genitalia thus exposed. Great modifications in the genitalia occur within a single instar, and an attempt was made to give a rather detailed account of these modifications in the fifth instar.

The writer wishes to express her appreciation to all who have assisted her in this work. Professor Hunter has always been most kind in helping in whatever way possible. Dr. Paul B. Lawson, under whose direction the work was done, has given freely of his time and experience. Kathleen Doering, Philip Readio and Robert Guntert are also deserving of thanks for their interest and assistance.

LIFE HISTORY NOTES.

The following are some of the references to this species:

Tettigonia hieroglyphica Say, Jl. Acad. Nat. Sci. Phila., vi, p. 313, 1831.

Tettigonia hieroglyphica Sig?, Ann. Soc. Ent. Fr., ser. 3, iii, p. 805, 1855

Tettigonia hieroglyphica G. and B., Hemip. Colo., p. 81, 1895.

Tettigonia hieroglyphica Ball, Proc. Ia. Acad. Sci., viii, p. 51, 1901.

Tettigoniella hieroglyphica Van D., Trans. San Diego Soc. Nat. Hist., ii, p. 52, 1914.

Tettigoniella hieroglyphica De L., Tenn St. Bd. Ent., Bul. 17, p. 20, 1916.

Cicadella hieroglyphica Van D., Cat. Hemip. N. A., p. 597, 1917.

Cicadella hieroglyphica Ols., Bul. Am. Mus. Nat. Hist., xxxvii, p. 3, 1918.

Cicadella hieroglyphica Lawson, Kan. Univ. Sci. Bul., xii, p. 85, 1920.

DESCRIPTION OF THE SPECIES.

The following is the original description:

Tettigonia hieroglyphica. Dull rufous; head and scutel lineated; hemelytra spotted.

Inhabits Arkansas.

Body obscurely dull rufous; head with a black dot at tip, above literate with black; thorax with a dusky posterior disk; scutel with black more or less curved lines; hemelytra obsoletely spotted, nervures being pale; beneath pale yellowish; pectus with large black spots; feet immaculate; tergum blue-black, edge yellow Length to tip of hemelytra one-fifth of an inch.

Dr. P. B. Lawson, in his paper on the Cicadellidæ of Kansas, gives the following description of the species:

Form. Rather stout. Length, 6 to 7 mm. Vertex bluntly conical, wider than long. Pronotum nearly twice as wide as long, posterior angles broadly rounded, posterior margin medially emarginated. Elytra broad, but exceeding the abdomen.

Color. Varying from brick red to greenish and slaty blue. Black markings on vertex very strong and distinct, enclosing a light-colored T on basal half. Elytra with pale bands along the costal, claval and sutural margins.

External genitalia. Female: Last ventral segment about as wide as long, lateral margins triangularly produced; pygofers long and narrow, equaling or slightly exceeding ovipositor, bearing a few stout hairs. Male: Last ventral segment less than twice as wide as long; plates long, broad at base, but tapering to long acute apices, margins fringed with short hairs; pygofers long and narrow, equaling or exceeding plates and bearing stout hairs.

Internal male genitalia. Styles short, distinctly bent in at point of attachment to connective by a large, heavily chitinized lobe, then curving outward and tapering gradually to blunt apex, with an outwardly projecting process; connective slender, Y-shaped, stem of Y broadening to broad base; œdagus with pair of short processes extending dorsad from its point of attachment to connective, a long process leaving it dorsally from a point a little past its middle, and a similar longer one leaving it apically, the latter to the left of the former. These two processes are narrow and long, narrowest at the base, and widening to a point shortly before the apex, where they are the widest, the right one wider than the left one, and then tapering to the acute tips. A pair of somewhat narrow triangular chitinous processes extend from the base of the anal tube to the main body of the œdagus.

Hosts. Taken abundantly on willows.

The following variety occurs along with the typical forms:

Cicadella hieroglyphica var. *dolobrata* (Ball). Its bibliography follows:

Tettigonia hieroglyphica var. *dolobrata* Ball, Proc. Ia. Acad. Sci., p. 52, pl. 3, fig. 2, 1901.

Tettigonia hieroglyphica var. *dolobrata* DeL., Tenn. St. Bd. Ent., Bul. 17, p. 20, 1916.

Cicadella hieroglyphica var. *dolobrata* Van D., Cat. Hemip. N. A., p. 597, 1917.

Cicadella hieroglyphica var. *dolobrata* Ols., Bul. Am. Mus. Nat. Hist., xxxviii, p. 3, 1918.

Cicadella hieroglyphica var. *dolobrata* Lawson, Kan. Univ. Sci. Bul., xii, p. 86, 1920.

Doctor Lawson describes this variety as follows:

This is a smaller form than the preceding, appearing more robust. In color it is typically black, retaining a few of the lighter markings of the typical *hieroglyphica* on the front, vertex, pronotum and scutellum, and generally having the claval sutures light.

Genitalia as in the preceding form.

Distribution: Occurs along with the typical form.

Hosts: Willows.

DISTRIBUTION.

Doctor Ball gives the following: "This species, as a whole, is very variable in size and color and recalls *Oncometopia undata* and *lateralis* in their red, green and black forms. The varieties readily fall into two series on structural characters. The first has *hieroglyphica* and *dolobrata* as the extreme in darkening up. These

forms are the only ones found in the Mississippi valley and as far west as central Kansas; they occur also in Texas, Arizona, and Mexico."

Van Duzee reports it from Kansas, New Mexico, Texas, Illinois, Missouri, Iowa, Nebraska, and Arizona.

HOSTS.

Cicadella hieroglyphica may be found on several hosts. Willows (*Salix longifolia and Salix amygdaloides*) are the most common of these, but it is frequently found on poplar (*Populus monilifera*). Occasionally it has been taken on the broad-leafed milkweed (*Asclepias syriaca*) and on giant ragweed (*Ambrosia trifida*).

HIBERNATION.

During the winter the adults hide among the fallen leaves and rubbish on the ground, and appear very sluggish when disturbed. On mild, sunshiny days in January numbers have been observed sunning themselves upon the stems.

SPRING APPEARANCE.

About the middle of February, or when the willows are first beginning to bud, the greater number are to be found on the branches and stems of the willows. They are very gregarious, and often are so clustered together as to completely hide the stem. At this time of year they feed by sucking the sap from the stems, and give off honeydew in such quantities as to cause a noticeable spray. Upon close observation this honeydew is seen to be given off in a rapid succession of droplets from the anal tube. Several specimens were timed in the operation, and from fifteen to thirty drops were given off per minute. This continues for several hours at a time while the insect is feeding. Frequently this operation is accompanied by a spasmodic raising and lowering of the wings, movements of the abdomen, and stroking of the wings and abdomen by the long metathoracic legs.

MATING AND OVIPOSITION.

(Plate XVII, figs. 1-4.)

Early in April mating takes place. By this time the willow buds are beginning to unfold and oviposition begins. Numbers have been watched ovipositing, both in the field and in the laboratory, and the following observations made.

The eggs are inserted in the tissues of the upper surface of the leaf just under the epidermis. In the act of ovipositing the female

braces herself firmly, at times using her beak in addition to her legs for this purpose. In all cases observed she always worked head up. She first unsheaths her ovipositor, punctures the epidermis with its tip, and then inserts it to its full length. The flat surface of the ovipositor now rests parallel to the flat surface of the leaf, with its toothed edge pointing forward. Sawing the ovipositor back and forth she increases the size of the slit until it is large enough for the egg. The egg then passes between the valves of the ovipositor into the chamber prepared for it, and the ovipositor is withdrawn and sheathed. In a very few seconds the process is begun again.

The time taken up in preparing the chamber and depositing the egg varied in several cases observed from two to five minutes, most of which time was spent in preparing the chamber. To cite a characteristic case, the whole operation occupied two and one-half minutes, the two minutes being spent in preparing the chamber and the half minute in placing the egg.

The eggs may be laid singly or side by side in even rows. The largest number found in a single row was twenty-five and the largest number in a single leaf was thirty-five. The eggs in a hundred rows or masses were counted, and the average number per row was found to be seven.

The effect of oviposition on the leaves is noticeable. The greater number of eggs are laid in leaves not fully developed, and the presence of the eggs causes the growing leaf to become distorted and to curl around the eggs. However, in no case observed did oviposition kill the leaf. Eggs have been found in both willow and poplar leaves.

NYMPHS.

(Plate XVI, figs. 1-6.)

Soon after oviposition, nymphs may be found feeding on the leaves. Eggs observed in the laboratory hatched in from eight days to two weeks. During their nymphal life these little leaf hoppers molt five times and become adult in a little over two months, or about the middle of June. By the middle of May the adults of the overwintering generation are all dead. Shortly after becoming adult, the new adults mate and another generation is completed by the end of summer. This generation consists of the overwintering individuals. Nymphs of this generation have been found abundantly on giant ragweed and goldenrod, and in all probability the eggs for this generation are laid in these hosts.

DESCRIPTION OF THE INSTARS.

For the description of the various instars an attempt was made to select an average indivdual. It is possible to separate the males and females of the same instar by an examination of the ventral surface of the eighth and ninth abdominal segments. This is discussed later in greater detail under the development of the genitalia of each sex. Except for this, and a slight difference in size, the female being the larger, the two sexes are practically the same.

Egg.

(Plate XVII, fig 1)

Length, 1 25 mm. Greatest width, .41. Subovoid in shape, somewhat pointed at one end, greenish yellow at first; just before hatching deeper yellow with dark eyespots

First Instar

(Plate XVI, fig 1)

Length, 2.65 mm Width across eyes, 65 mm Pale yellowish white, eyes black and prominent, anterior margin of head evenly rounded, two pairs of wing pads present, first pair short, barely covering base of second pair, caudal margin in form of an inverted W, with median projection extending farther caudad than lateral projections, exposed portion of second pair more than twice as long as first pair, caudal margin nearly straight, the segments marked off by light brownish bands.

Second Instar.

(Plate XVI, fig 2)

Length, 3 15 mm. Width across eyes, 9 mm. Color same as in first instar, margin of head similar; wing pads have increased in length and width, but relative shape and position are the same, caudal margin of second pair bent slightly cephalad medially.

Third Instar.

(Plate XVI, fig 3)

Length, 4 25 mm. Width across eyes, 1 mm Color and shape of head unchanged; wing pads show decided change in length and width, lateral angles of first pair produced caudad and much longer than median projection; exposed length of second pair but little longer than first pair.

Fourth Instar.

(Plate XVI, fig 4)

Length, 5 3 mm Width across eyes, 1 35 mm. Color and shape of head practically the same as in preceding instars; lateral angles of first pair of wing pads now reach almost to the apex of the second pair; lateral angles of second pair have now extended farther caudad, making median indentation in caudal margin more pronounced, do not extend beyond second segment of abdomen.

Fifth Instar.

(Plate XVI, fig. 5.)

Length, 6.4 mm. Width across eyes, 1.4 mm. Color the same, head becoming slightly more pointed, markings more distinct; lateral angles of first pair of wing pads still further produced and are now about the same length as second pair; lateral angles of second pair also further produced caudad and now extend almost to fourth abdominal segment.

Adults.

(Plate XVI, fig. 6)

The second generation, or the overwintering one, consists of the typical reddish adults. The sexes can be easily distinguished one from the other by the darker color of the male abdomen as contrasted with the lighter color of the female's. These produce the slaty-gray individuals of the summer generation. The black form, the variety *dolobrata,* is also present at this season. However, only males of this form have been found. They mate with the slaty-gray individuals, which are for the most part females, although males of this type are numerous. Very evidently, the dark forms are dimorphic males of the summer generation. A single dark male was taken April 1 with the overwintering red forms, but whether this is one of the summer forms which has overwintered or one of the wintering generation which differs in color from the rest of the generation has not been determined.

MORPHOLOGICAL STUDIES.

GENERAL DESCRIPTION OF THE ABDOMEN.

(Plate XVIII, figs. 1-3; 6-9.)

The abdomen is joined broadly to the metathorax. It continues at the same width for about two-thirds of its length, and from there tapers to a somewhat pointed apex. In a general cross section it is semicircular in outline. The sternite and the pleurites, ventral in position, form the straight part of the semicircle, while the curved, dorsal tergite forms the circular part. Eleven segments can be accounted for. In the male, six of these are represented by complete sternites, pleurites and tergites, but in the female only five are so represented. In the first two segments only the sterna and terga are present, the pleura being represented by pleural membranes. Segments three to eight in the male and three to seven in the female are typical. The terminal segments in both sexes are modified. These modifications are discussed under the heading "external genitalia" in the description of the species. In addition to what is given there, I should like to add that the ventral valve of the adult is present, but concealed by the last ventral segment.

DEVELOPMENT OF MALE GENITALIA.

(Plate XIX, figs. 2, 4, 6, 8, 10, 12; Plate XX, figs. 1-18.)

The male genitalia, consisting of three pairs of valves arise from a genital area on the ninth abdominal segment. In the first, second and third instars there are two pairs of valves present. These develop in small chitinous pockets, which are attached at the caudal edge of the genital area with their apices directed caudad. The genital area increases slightly in size in each successive instar, as do the pockets. The pockets are placed one upon the other, the ventrally placed pocket producing the plates of the adult and the more dorsal pair the œdagus. The ventral pair is about twice as long as the dorsal. Both taper caudad, and are somewhat rounded at the apex. Each pair is divided into its right and left valve by a chitinous median partition.

In the fourth instar there is, as in the former instars, a noticeable increase in size, both of the genital area and of the ventral and dorsal pockets. In addition to these structures, there is now present a pair of small lateral pockets located at the lateral margin of the genital area, and extending caudad as far as the bases of the dorsal pockets. In these lateral pockets develop the styles of the adult genitalia. In the fifth instar there is no great change in the relative position and shape of the pockets. There is, of course, a natural increase in the size of all three pockets.

In the fifth instar the greatest changes in the developing genital appendages take place. The three pairs of valves may be traced through several distinct phases of development by a study of the soft, white integument which can be drawn from the chitinous pockets. Details of five particular phases might be mentioned. (Plate XX, figs. 6-18.)

The ventral plates which develop in the ventral pockets show very little change throughout the successive phases of this instar.

The styles which develop in the lateral pockets are present in all five phases and show a gradual increase in size through the phases. In the fourth phase they first show their permanent attachment to the ventral plates, which is more apparent in the fifth phase and in the adult. They are attached on their outer edges near the base of the plate.

The developing œdagus or the integument drawn from the dorsal pockets shows the most remarkable alterations. In phase 1 the œdagus consists of two valves placed parallel to the ventral plates.

In phase 1, ventral aspect, the valves placed side by side are comparatively narrow at their bases, widest at a point a little before the middle, and then tapered to somewhat pointed apices. Dorsally they do not appear to extend as far cephalad as they do ventrally, nor are they divided into right and left valves except for a short distance apically, at which point they are widely separated.

In phase 2, viewed ventrally, the two valves have become longer and slightly narrower than in the preceding phase, and instead of their former relationship, side by side, the right valve at the base is now assuming a ventral position with respect to the left valve. Also, the flat surfaces of the valves, instead of being parallel to the ventral plates, are now assuming a perpendicular position. Between the valves, at a point a little beyond the middle, a short, slender finger-like process is visible. Viewed dorsally, this process appears between the two valves at the point of wide separation in phase 1 and projects for a short distance caudad. It is an evagination of the integument of the valves.

In phase 3, ventral aspect, the two valves have continued to increase in length. The right valve is distinctly folded over the left valve at the base. A lateral aspect shows plainly the relative position of the median process and the valves. In phase 3, dorsal aspect, there is little change in the valves except an increase in length. The median process also shows an increase in length and width.

In phase 4, ventral view, the valves again are longer than in the preceding phase, and the median process also shows a distinct increase in length. The folding of the right valve over the left valve is more complete, and the bases of the two valves are farther apart than in the preceding phase, the left valve having moved caudad.

In phase 5 the œdagus appears very similar to the adult œdagus. Here the valves have become very much longer than in phase 4. The median process has increased greatly in length.

During the development of the valves their apices have maintained their relative length in respect to the ventral plates. The increase in length has been taken up by increased dorsal curvature.

For a description of the adult male internal genitalia, reference may be made to the description of the species.

DEVELOPMENT OF THE FEMALE GENITALIA.

Ovipositor of Adult.

(Plate XVIII, figs. 4-6)

In the female the genitalia also consist of three pairs of appendages. They are the ventral and dorsal pairs, which make up the ovipositor proper, and the lateral pair, within which the ovipositor is folded. The ventral pair arise from the eighth sternum, and the dorsal and lateral pairs arise from the ninth sternum, the dorsal pair from its cephalic margin and the lateral pair from its caudal margin.

The ventral valves arising from the eighth sternum are two long, slender valves, tapering caudad and sharply pointed at the apices. They are ventral in position and inclose the dorsal valves. The ventral and dorsal valves of each side are joined one to the other by a tongue-and-groove arrangement, the tongue being on the dorsal valve and the groove on the ventral.

The dorsal valves are innermost of the three pairs and are dorsal in location. They consist of a narrow, curved, rodlike base, and a broader, flattened apical part which bears teeth along its dorsal edge. The apex is sharply pointed and bears very fine teeth on both dorsal and ventral edges. There are from seventeen to nineteen large teeth on the dorsal edge.

The lateral valves are the outermost of the three and enfold the other two pairs. They are broad, flat, and somewhat concave on their inner surfaces. They are not capable of extension as are the other two pairs, for in addition to being attached basally to the ninth sternum, they are also attached to the pygofers for about one-half their length. Their apical half is free.

Nymphal Genital Appendages.

(Plate XIX, figs. 1, 3, 5, 7, 9, 11)

In the first and second instars two pairs of very small chitinous pockets may be seen, one projecting caudad from the eighth sternum and the other from the ninth. In the first pair develop the ventral valves of the adult ovipositor, and in the second the dorsal valves. In these two instars the apices of the ventral pockets are at a distance from the bases of the dorsal pockets. The dorsal pockets, extending caudad for about one-third the length of the ninth segment, are also short.

In the third instar the ventral pockets have increased in length and width. They are still short and broad. Their broadly rounded

apices overlap the bases of the dorsal pockets. The narrower, longer dorsal pockets extend caudad for about one-half the length of the ninth segment. In this instar the lateral pockets first appear. They lie laterad of the dorsal pockets, are slightly curved and somewhat narrower and shorter than these.

In the fourth instar the ventral pockets are longer than in the preceding instar, and are now more than two-thirds the length of the dorsal pockets. The ventral, still the longer of the two pairs, are about the same distance from the tip of the ninth segment. They are beginning to be enfolded by the lateral pockets, which have broadened and are now somewhat concave on the inner surface. The lateral pockets are longer than the ventral pockets, but shorter than the dorsal.

In the fifth instar the three pairs of pockets are rather darkly chitinized. The ventral pockets are broad at the base and taper gradually to narrowly rounded apices. They are the shortest of the three pairs, though nearly as long as the dorsal pair. Only the extreme apices of the dorsal pockets are visible, their basal portion being hidden by the broader ventral pockets. They are still longer than the ventral pockets, but are now exceeded in length by the lateral pockets. These are somewhat spoonlike and have more completely enfolded the dorsal pockets.

PLATE XVI.

1. First instar.
2. Second instar.
3. Third instar.
4. Fourth instar.
5. Fifth instar.
6. Adult.

PLATE XVI.

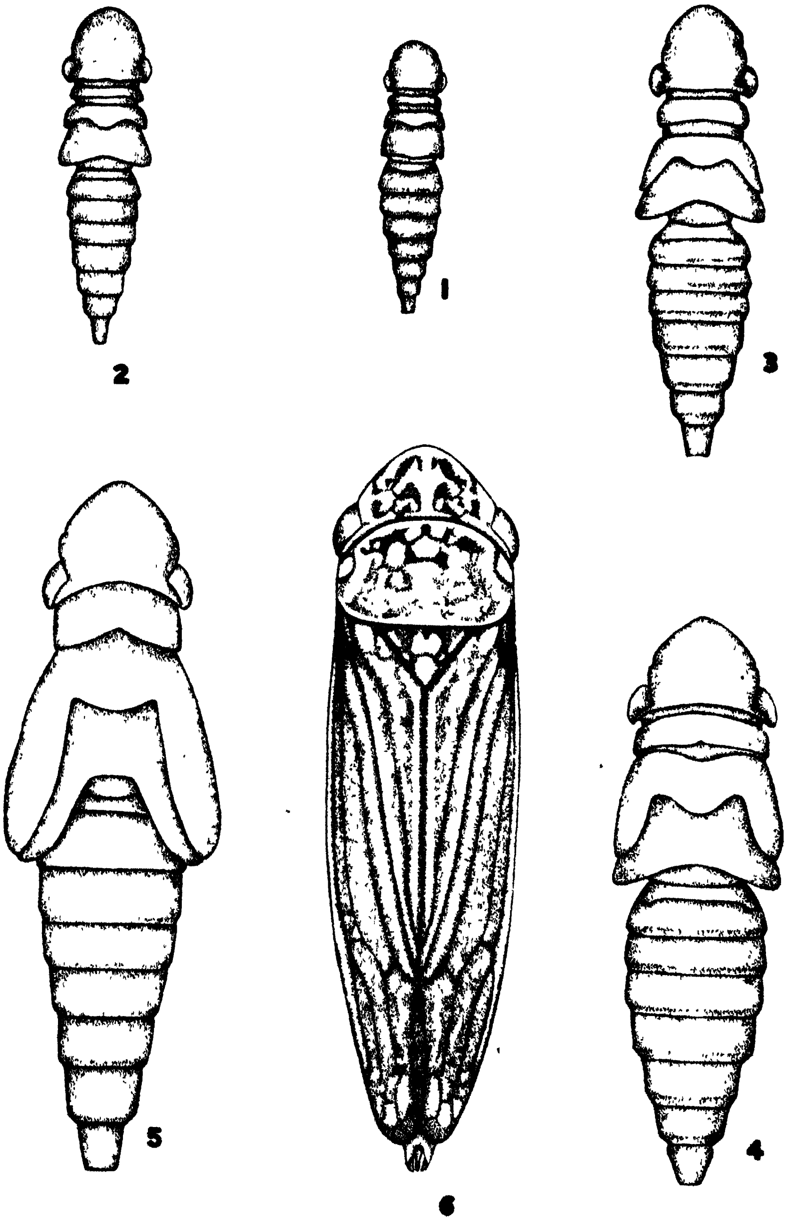


PLATE XVII.

1. Egg enlarged.
2. Leaf with two egg masses
3 Leaf showing effect of oviposition.
4 Twig showing effect of oviposition

PLATE XVII.

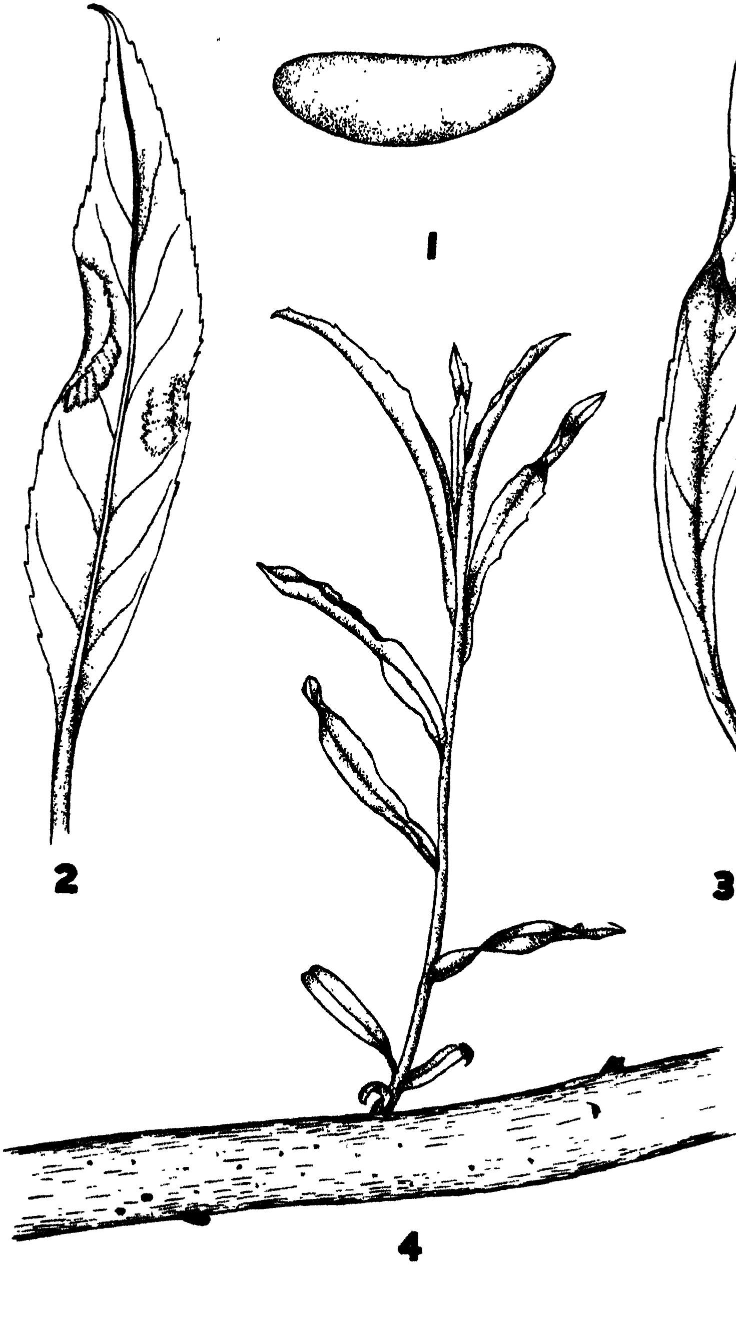


PLATE XVIII.

1. Abdomen of adult female.
2. First sternite of female abdomen.
3. Second sternite of female abdomen.
4. Ventral valve of ovipositor attached to eighth sternum.
5. Dorsal valves (upper) and lateral valves (lower), showing attachment to ninth sternum.
6. Terminal segments of female abdomen, showing ovipositor
7. First sternite of male abdomen.
8. Second sternite of male abdomen.
9. Abdomen of adult male.
10. Cephalic view of main body of œdagus.
11. Caudal view of main body of œdagus.
12. Œdagus, showing attachment of ejaculatory duct.
13. Styles and connective.
14. Ventral valves, dorsal aspect, showing attachment of styles.
15. Male genitalia.

PLATE XVIII.

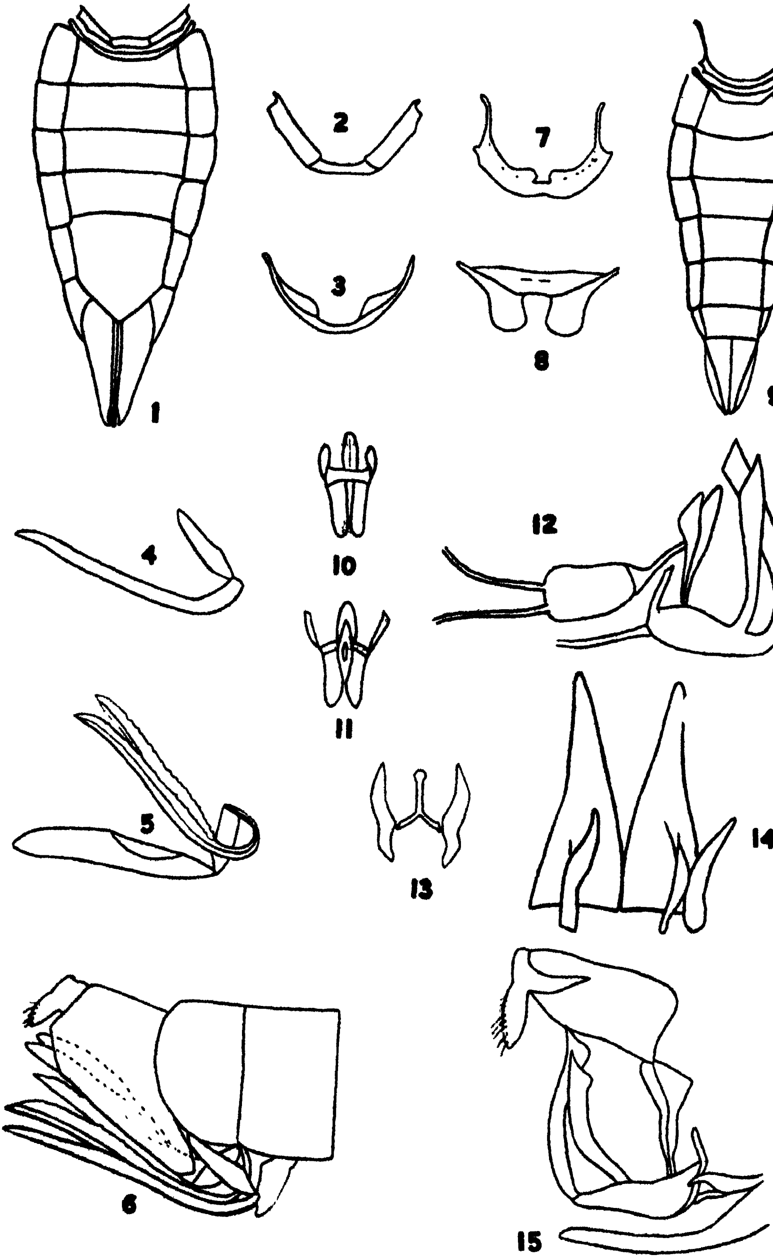


PLATE XIX.

TERMINAL SEGMENTS OF ABDOMEN:

1. Female, first instar.
2. Male, first instar.
3. Female, second instar.
4. Male, second instar.
5. Female, third instar.
6. Male, third instar.
7. Female, fourth instar.
8. Male, fourth instar.
9. Female, fifth instar.
10. Male, fifth instar.
11. Female adult.
12. Male adult.

PLATE XIX.

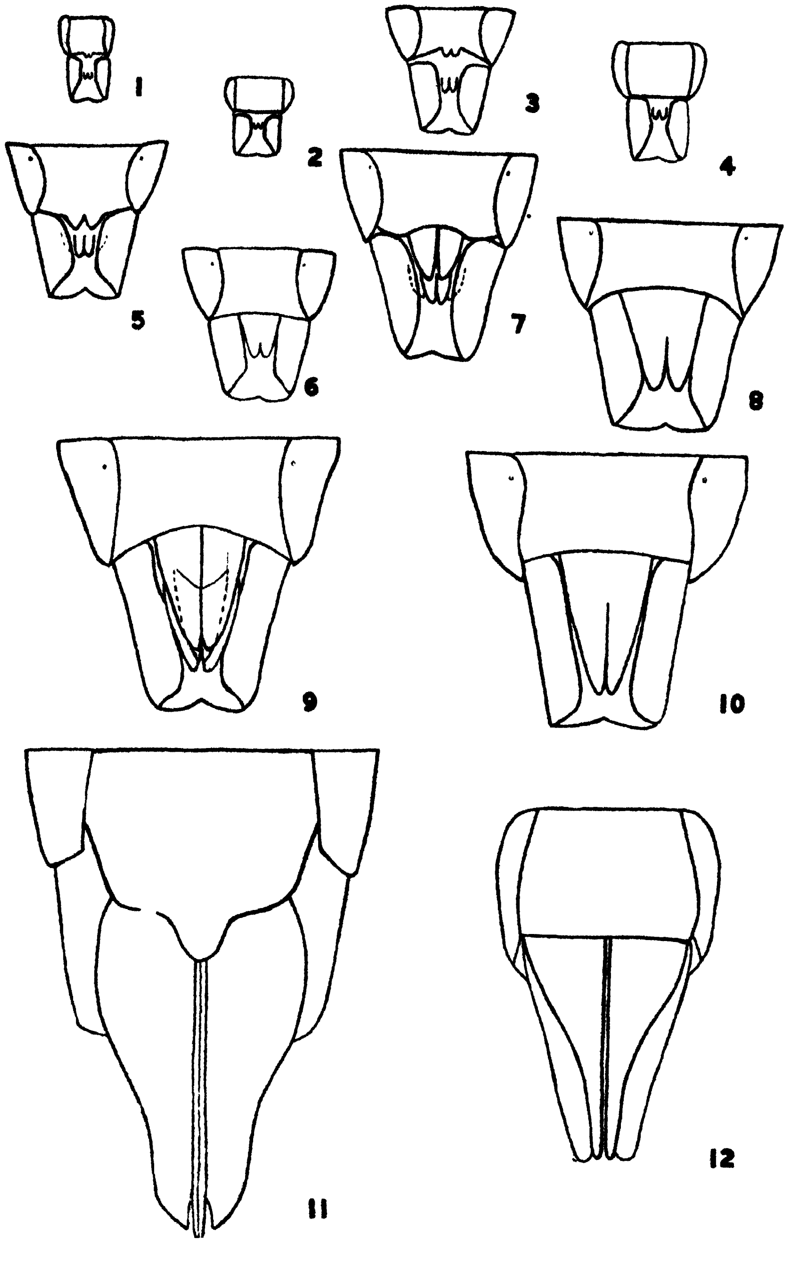
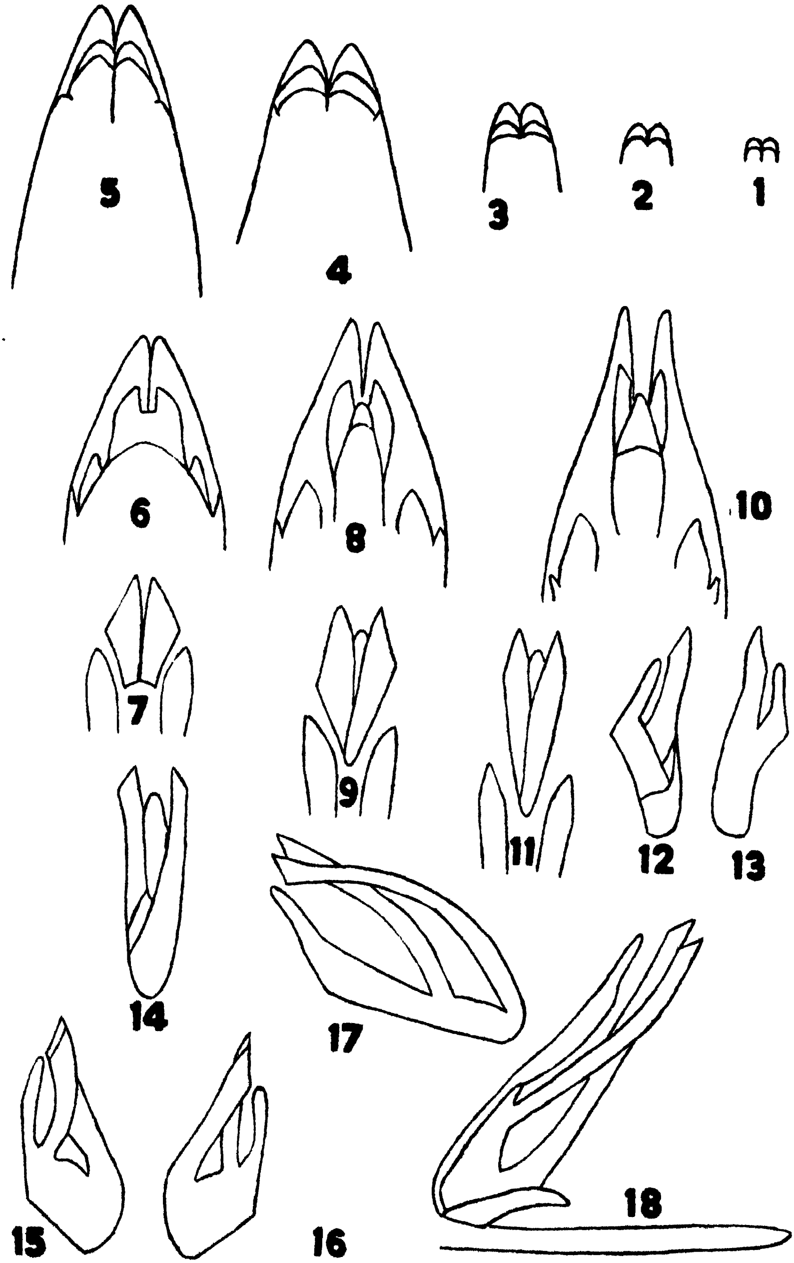


PLATE XX.

DEVELOPMENT OF MALE INTERNAL GENITALIA:

1. First instar.
2. Second instar.
3. Third instar.
4. Fourth instar.
5. Fifth instar.
6. Fifth instar, phase 1, dorsal view.
7. Fifth instar, phase 1, ventral view.
8. Fifth instar, phase 2, dorsal view.
9. Fifth instar, phase 2, ventral view.
10. Fifth instar, phase 3, dorsal view.
11. Fifth instar, phase 3, ventral view.
12. Fifth instar, phase 3, lateral (right) view of œdagus.
13. Fifth instar, phase 3, lateral (left) view of œdagus.
14. Fifth instar, phase 4, ventral view of œdagus.
15. Fifth instar, phase 4, lateral (right) view of œdagus.
16. Fifth instar, phase 4, lateral (left) view of œdagus.
17. Fifth instar, phase 4, lateral (right) view of œdagus.
18. Fifth instar, phase 4, relative position of plates, styles and œdagus.

PLATE XX.



THE

KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV, NO. 8—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No 8.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

TABLE OF CONTENTS.

THE KANSAS UNIVERSITY SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 8.

The Ovipositors of the Cicadellidæ (Homoptera).

BY PHILIP A. READIO.

Submitted to the department of entomology and to the graduate faculty of the University of Kansas in partial fulfillment of the requirements for the degree of master of science, May 15, 1922.

INTRODUCTION.

THE primary purpose of this paper is to determine whether or not the ovipositors of the Cicadellidæ possess characters of value in classification, and if so, of how much value these characters are and how accessible they are to the general worker. To Prof. Paul B. Lawson belongs the credit for suggesting the paper. In the same group he has recently found that the male genitalia are of much value in classification, and the possibility of equal value in the female genitalia occurred to him. Miss Itasca Hilsman, working in the closely related family, Cicadidæ, found that the ovipositors in this group "afford constant and ready characters which may at times be of decided value to him (the specialist) in the determination of closely related species." Hence it was natural to expect that equally favorable results might be obtained from a study of the ovipositors of the Cicadellidæ. As an introduction to the taxonomic part of the paper, a morphological study of the abdomen of the female and the structure of the ovipositor was made.

In addition to the reasons already stated, there are certain general considerations which would lead one to expect such an investigation as this one to be fruitful. It is constant characters that the taxonomist is in search of—characters that are sufficiently definite to separate closely related species, and yet are present in the entire range of the species. Because of their internal position, genitalia are more likely to be constant than external structures, which may vary with differences of environment. The constancy of the use to which genitalia are put also makes for the permanency of their structure and their usefulness as taxonomic characters.

The material necessary for this study was obtained from the duplicate collection of the University of Kansas entomological museum. A representative number of ovipositors from each of the subfamilies, excepting the Paropinæ, was examined, and an attempt made to examine as many different genera and as many species in each genus as possible. In all, representatives of forty-eight genera and ninety-two species were examined and figured.

The writer wishes to express to Prof. S. J. Hunter his appreciation of the sanction given to this work, and of the necessary time and materials so kindly placed at his disposal. To Prof. P. B. Lawson many thanks are due, both for the conception of the nature of the problem and for the direction of the work to its completion. It was under the able direction of Prof. P. W. Claassen, of Cornell University, that the photography was done. To Prof. H. B. Hungerford, Miss Lucy Hackman, Miss Kathleen Doering and Mr. Robert Guntert the writer wishes to express his appreciation for their kind help, suggestions and criticisms.

THE ABDOMEN OF THE FEMALE.

(Pl. XXI, figs. 1-3.)

For a study of the abdomen of the female leaf hopper, dried specimens of *Oncometopia lateralis* (Fabricius) were used. These were soaked in caustic potash, ten per cent, for twenty-four hours, and drawings and descriptions made from the cleared specimens.

The abdomen joins the thorax broadly, bulges slightly in the middle, and, from a point a little past the middle, tapers both in width and in height to a blunt, caudal point. A cross section has a general semicircular outline. The tergum is arched, appears dorsally and laterally, and forms the rounded portion of the semicircle, while the pleura and sternum are flat, and form the flat, ventral portion. The lateral edges of the sternum are bent slightly dorsad at their union with the pleura. The pleura and tergum unite at a distinct but slightly rounded angle.

Eleven segments can be accounted for in the abdomen. Of these, segments one and two lack distinct pleura, and segments eight to eleven are variously modified as described.

The tergum of the first segment is partly membranous and partly chitinized. Cephalad, at its junction with the metathorax, it is entirely membranous. Caudad, at its junction with the second abdominal segment, is a narrow, linear, chitinized sclerite which bears laterally two inwardly projecting processes along its cephalic border.

Between the inwardly projecting processes is a round, small, chitinized piece. The pleura are entirely membranous, and in the pleural membranes, opening ventrally, are the spiracles of the first segment. These are larger than those of the other abdominal segments. The sternum consists of a curved, lightly chitinized caudal sclerite extending for nearly the entire width of the segment, and of a membranous cephalic portion connecting with the metathorax. The chitinized portion has along its cephalic border two pointed projections which point mesad.

The tergite of the second segment consists of a simple, linear; chitinized sclerite which extends nearly the entire width of the segment. It is about one-third the length of the third tergite. The pleura are represented only by pleural membranes in which the spiracles of this segment are located. The spiracles open dorsally and appear to be in the membrane laterad of the second tergite. The sternum of segment two is a curved, chitinous piece extending the entire width of the segment.

Segments three, four, five and six have distinct and complete terga, sterna and pleura. The terga are arched and form the dorsal and lateral surfaces. The ventral surface is formed by the pleura, which are subrectangular and longer than wide, and by the sterna, which are also subrectangular, but wider than long. Each pleuron bears a spiracle in a cephalomesal position. The fourth segment is slightly longer than the third, and the fifth and sixth are about the same length and longer than the fourth.

Segment seven is also complete. The tergum and pleura are the same as in the preceding segments. The sternum forms the subgenital plate and is commonly called the last ventral segment. Its lateral margins converge caudad and its caudal border bears a broad but shallow indentation along its mesal half. Dorsad of the sternum of segment seven is an invaginated pocket in which the bases of the valves of the ovipositor are located. Its ventral side is formed by the apical portion of the seventh sternum and a membrane arising from the dorsal surface of this sclerite and extending cephalad to its base. The dorsal side of the pocket is formed by a membrane which is continuous with the membrane of the ventral side, and which extends caudad to the eighth sterna with which it connects. The greater part of this dorsal membrane is strongly chitinized, but medially it is apparently divided by a narrow, clear line which expands apically into the entirely membranous apex connecting with

the eighth sterna. Laterally this pocket is bounded by the continuation of the dorsal membrane to the seventh and eighth pleura. The anterior portions of these lateral membranes are strongly chitinized and curve mesad ventrally.

The terminal segments of the female abdomen bear the external organs of reproduction and are modified for this purpose. Segment eight is represented externally only by the tergum and the pleura. The tergum is essentially the same as in the preceding segments, but narrows slightly caudad. The pleura narrow caudad and are triangular in shape. They include the ventral cephalic portion of the ninth segment between them and bear the last pair of spiracles. Externally segment nine consists only of a tergum, commonly called the pygofer, which almost completely encircles the abdomen, leaving only a ventral groove in which the ovipositor is folded. Ventrally it extends cephalad, ending in two obtuse points between the eighth pleurites. The caudal portion encircles nearly the whole segment and tapers towards its caudal end.

The anal tube is composed of segments ten and eleven. Segment ten arises from the narrowed apex of segment nine and is short and tubular. It connects by a distinct intersegmental membrane with segment eleven, which is also tubular and can be telescoped within segment ten. Segment eleven bears the telson, the extreme apical portion of the abdomen. Along the dorsal edge of the telson is the anus, an opening running for its entire length and guarded by hairs.

There are eight spiracles in the abdomen of the female located in the first eight segments as described.

Along the ventral side of the abdomen there occur many short, fine hairs, which in all cases point backward. The hairs on the ninth segment, or pygofer, are somewhat longer than those on the other parts of the abdomen.

THE OVIPOSITOR.

(Pl. XXI, figs. 4-9.)

This description was made from the ovipositor of *Oncometopia lateralis* (Fabricius). However, in the many other species of leaf hoppers examined, the fundamental structure of the ovipositor was found to be the same as for the species here described.

The ovipositor of the leaf hopper is fitted for sawing slits in plant tissues and for placing eggs within these slits. When not in use it lies in the groove in the ventral surface of the ninth segment. The ovipositor consists of three pairs of valves or gonapophyses. The

inner two pairs alone function in sawing slits and placing eggs, and the outer pair act as guards within which the two inner pairs lie when not in use. In this discussion the valves are numbered I, II and III, according to their attachment, the most cephalic in attachment being numbered I.

Valve I is the outer and more ventral of the two inner pairs of valves. Its chief attachment is to the eighth sternum, which is divided and appears as two subrectangular, heavily chitinized sclerites, for the most part hidden in the pocket above the seventh sternum. Near its base, a narrow, curved rod leaves its dorsal margin and attaches basally to a small, triangular sclerite on the dorsal side of the cephalic end of the pygofer. This small triangular sclerite is possibly the ninth pleurite. Upon attempting to separate the narrow, rodlike portion from the rest of the valve, a featherlike structure, consisting of a middle portion formed by the continuation of the attaching rod and membranous side plates, can be drawn out. However, except basally, this featherlike structure is entirely incorporated into the main part of the valve, both structurally and functionally. The main part of the valve is relatively broad basally, narrows slightly beyond the base, broadens again towards the middle, and narrows to a sharp, apical point. A heavily chitinized rod strengthens the ventral portion of this valve. The rod is comparatively large basally, narrows in the middle portion, and is absent in the apical third. Along the entire dorsal border and along the ventral apical border are diagonal rows of scalelike processes. Along its mesal surface, just dorsad of the chitinized rod, is a mushroom-shaped groove into which a complementary tongue on the outer surface of valve II fits. This permits independent sliding of the two valves, but not complete separation. Basally the ventral edges of this valve turn mesad, and on the dorsal side of this inturned portion is a less heavily chitinized projection. This projection in the one valve bears a tongue, and in the other a groove, uniting the two basally. For the greater part of their length, however, they are independent.

Valve II is the inner and the more dorsal of the two inner pairs of valves. It is attached to the cephalic end of a small sclerite, which is attached to the pygofer. This sclerite is ventral in position and possibly represents the ninth sternite. This valve is narrow and rodlike at the base, but for its greater length is broad and flat. It also possesses a chitinized strengthening rod which extends nearly to its apex. On the outer surface of the valve, just ventrad of the rod, is a tongue which fits into the groove in valve I. The dorsal

edge usually bears teeth, which may extend for its entire length, be confined to the apical half, or appear only at the tip. The teeth are of various shapes in the different species, and may or may not in turn bear secondary teeth. The pointed tip is usually notched with small teeth, and these may appear on either the dorsal or ventral or both sides. From the interior of the valve certain ductlike structures lead to the dorsal and apical teeth. The function of these ducts is unknown. This pair of valves is usually united one to the other basally, sometimes by a heavy chitinized connection, sometimes only by a membrane, but not by a tongue and groove.

Valve III is the most caudal in attachment, being attached to the caudal end of the same sclerite to which valve II is attached. There is also a membranous connection between this valve and the ventral side of the pygofer for about half the length of the valve. The proximal half of the valve is narrow and the apical half broad and spoonlike, being somewhat concave on its inner surface. It is bluntly rounded at the apex. This pair of valves, between which there is no connection, forms a protecting sheath in which the ovipositor is completely encased when not in use.

Oviposition of *Cicadella hieroglyphica* (Say) has been observed and the use of the ovipositor noted. Valve III remains in its position in the groove of segment nine and takes no part in the operation. Valves I and II, closely appressed and appearing as a single structure, are extruded from their resting place and form the functional part of the ovipositor. The ovipositor is first held vertically and its tip inserted under the epidermis of the leaf. It is then pushed in to nearly its full length, and now is in a horizontal position, the flat surface of the ovipositor being parallel with the flat surface of the leaf. The teeth on the dorsal edge of the ovipositor are now turned cephalad. The ovipositor is pushed backward and forward with a sawlike motion until the chamber is large enough for the reception of the egg. The egg passes out between the valves of the ovipositor and into the chamber, and when in place, the ovipositor is withdrawn and folded into its resting place.

TAXONOMIC USE OF THE OVIPOSITOR.

In the search for characters of taxonomic value in the ovipositor, valve II was at once hit upon as being the structure most likely to possess useful characters. It varies in different species in regard to size, shape, number and shape of primary teeth, number and shape of the secondary teeth borne by the primary teeth, characters of the tip, and in the number and arrangement of the ducts. That these

characters are constant within the species has been proven by examining a wide range of individuals within the species and finding that the variation was negligible. Consequently, for the taxonomic part of this paper, valve II is used exclusively.

The technique used in mounting valve II for study is simple. The tip of the abdomen bearing the ovipositor is broken off from the dried specimen, soaked in ten per cent caustic potash for twenty-four hours, washed in water for a few minutes, valve II and other desired parts dissected out under a binocular microscope, dehydrated in ninety-five per cent alcohol for five minutes, cleared in xylol for five minutes, and mounted in balsam on a microscope slide. It is well to give the slide and the specimen from which the slide was made a corresponding number, so that any necessary checks may be made. This method gives a permanent mount, which may be studied at the convenience of the worker.

Several methods of figuring the ovipositor were used. The first was that of drawing the desired valve free-hand with the aid of a micrometer eyepiece divided into squares, which correspond to squares on the drawing paper. This is a satisfactory method, but somewhat more laborious than the methods later used. The second was to draw with the aid of the camera lucida. The particular equipment available did not give satisfactory results at all times, but there is no doubt but what this method could be used with satisfaction. The greatest degree of success was obtained by the use of the Edinger drawing apparatus. This apparatus projects the desired image upon the drawing paper, and the figuring consists only of tracing in the image. Photography was tried and found to be a very successful means of reproducing the desired image. A camera fitted for ordinary scientific work was used. It was turned to a vertical position and a lens board fitted with a black, light-proof sleeve was inserted in the front lens-board holder. The sleeve was lowered over the ocular of a compound microscope, and focusing for desired size and definition of image accomplished by a combination of microscope and camera adjustments. Various substitutions in objectives and oculars were necessary to meet all conditions. Illumination was furnished by an ordinary substage light, and exposures were made by the switching off and on of this lamp. Undoubtedly much better results could be obtained with the aid of special photomicrographic equipment.

Descriptions of the ovipositors of the genera and species of the various subfamilies follow:

SUBFAMILY BYTHOSOPINÆ (Dohrn).

Agalliopsis novella (Say).

(Pl. XXII, fig. 2.; pl. XXV, fig. 1.)

Length, 1.1 mm.; greatest width, 0.11 mm. Apical toothed half only slightly wider than basal half; distinctly curved, tip rather gradually narrowed, extreme apex somewhat pointed, chitinization light; strengthening rod extends caudad as far as twenty-first or twenty-second dorsal tooth from apex. Toothed area on dorsal edge occupies slightly less than the apical half, teeth sixty-three to sixty-five in number, very small, angular, pointed, rather regular in size, shape and spacing; a few double teeth present, no secondary teeth; the tip is notched on both edges with small teeth, practically continuous around the tip, twenty to twenty-two on ventral edge; area of ducts inconspicuous, a few ducts faintly visible for their entire length, but for the most part are invisible except for their apices and circular openings, open along the ventral apical edge (seven), along the dorsal edge of the toothed area, and in the basal region; the two valves of the pair are joined one to the other by a narrow, elongate, chitinized connection present on the dorsal edge of the basal region at a point about two-fifths the length.

Aceratagallia uhleri (Van Duzee).

(Pl. XXV, fig. 2.)

Length, 1 mm.; greatest width, .07 mm. Apical half very little if any wider than basal half; distinctly curved, tip gradually narrowed, extreme apex rather pointed, chitinization moderately light; strengthening rod extends caudad as far as twenty-second dorsal tooth from apex. Toothed area on dorsal edge occupies the apical half of the length; teeth about ninety in number, very small, angular, pointed, fairly regular as to size, shape and spacing, larger apically; bear no secondary teeth; the tip is notched with small teeth on both edges, continuous around the tip, about twenty-two on the ventral edge; area of ducts conspicuous, ducts easily visible for entire length; open along ventral apical edge (five to six), along dorsal edge of toothed area, and in basal region; the two valves of the pair are joined one to the other by an elongate, narrow, chitinized connection present on the dorsal edge at a point about one-third the length.

This ovipositor is similar to that of *Agalliopsis novella* (Say) in general appearance.

Genus IDIOCERUS Lewis.

The ovipositors of seven species of this genus have been examined and found to be generally similar. In each case the ovipositor is about the same width for the entire length and is only slightly curved. Examples of light, medium and heavy chitinization are found. The valve may be toothed along its dorsal edge from a fourth to a little more than a half its length apically. The teeth in the specimens examined are ten to thirty in number, medium to large in size, rounded, evenly spaced, and may or may not bear secondary teeth. The ducts may appear ductlike, granular, or be

invisible. The apex may or may not bear small teeth along one or both edges. A chitinous connection is present on the dorsal edge of the basal area in some species.

Idiocerus nervatus Van Duzee.

(Pl. XXV, fig. 9.)

Length, 1.4 mm.; greatest width, 0.12 mm. Apical portion slightly wider than basal portion; slightly curved, tip greatly narrowed with the extreme apex bluntly rounded, very lightly chitinized; strengthening rod extends caudad as far as eleventh dorsal tooth. Toothed area on dorsal edge occupies the apical two-fifths of the length; teeth fourteen to sixteen in number, large, long, rounded, regular, evenly spaced, though somewhat farther apart basally; bear no secondary teeth, though the margin is irregularly roughened; the tip is notched on both edges with small, forward-pointing teeth, eight appear ventrally, one to three dorsally; area of ducts inconspicuous, circular openings alone visible; of these four open ventrally, three apically, and many dorsally. There is no evidence of a chitinous connection.

Idiocerus pallidus Fitch.

(Pl. XXII, fig. 1; pl. XXV, fig. 5.)

Length, 2.4 mm.; greatest width, 0.25 mm. About the same width for entire length; slightly curved, tip bluntly rounded, heavily chitinized; strengthening rod extends caudad as far as ninth dorsal tooth. Toothed area on dorsal edge occupies a little more than the apical third; teeth fourteen in number, large, rounded, regular, evenly spaced except basally, where they are farther apart; secondary teeth only on last eight primary teeth, these very small and indistinct, especially on those farthest from the tip, where they can be seen only with the aid of high-power magnification; the tip is notched with small, regular teeth on both dorsal and ventral edges; area of ducts conspicuous, ducts elongate, large, straight; six open along ventral apical edge, one in extreme apex, and many along the dorsal edge. A rather indistinct chitinous connection is present on the dorsal edge of the basal area and joins the two valves of the pair.

Idiocerus duzeei Provancher.

(Pl. XXV, fig. 6.)

Length, 2.6 mm.; greatest width, 0.34 mm. Apical portion slightly wider than basal portion; slightly curved, tip ends in somewhat rounded, obtuse point, heavily chitinized; strengthening rod extends caudad as far as sixth dorsal tooth. Toothed area on dorsal edge occupies a little less than the apical half, teeth nine to ten in number, large, somewhat angular, regular, evenly spaced, but larger and farther apart basally, teeth one and two being very large, rounded, and heavily chitinized; all the primary teeth except teeth one, two and three are notched with small secondary teeth; tip is notched with many small, regular teeth on both dorsal and ventral edges; ducts conspicuous, rather small, straight, open by circular openings; six open along the ventral apical edge, one in extreme apex, and many along the dorsal edge; there is no well-defined chitinized connection between the two valves of the pair.

Idiocerus verticis (Say).

(Pl. XXV, fig. 7.)

Length, 1.55 mm.; greatest width, 0.15 mm. Apical portion only slightly wider than basal; slightly curved, tip greatly narrowed with extreme apex rounded, chitinization light; strengthening rod extends caudad as far as fourteenth dorsal tooth. Toothed area on dorsal edge occupies a little more than the apical third; teeth twenty in number, large, rounded, regular, evenly spaced except basally; bear no distinct secondary teeth, though the margin is irregularly roughened suggesting secondary teeth; the tip bears ten small caudad-pointing teeth along its ventral edge; the ducts are inconspicuous, their circular openings alone being visible; of these apparently two open ventrally, three apically, and many dorsally; there is no distinct chitinized connection between the two valves of the pair.

Idiocerus scurra (Germar).

(Pl. XXV, fig. 8.)

Length, 2.22 mm., greatest width, 0.28 mm About the same width for entire length; slightly curved, tip narrowed but broadly rounded at the extreme apex, rather heavily chitinized; strengthening rod extends caudad as far as the twenty-fifth dorsal tooth. Toothed area on dorsal edge occupies a little more than the apical half; teeth thirty in number, moderately large, rounded, regular, evenly spaced, about the same distance apart for entire length; bear no secondary teeth; the ventral edge of the tip bears ten small teeth; area of ducts conspicuous, granular in appearance, circular openings visible; two open ventrally, two apically, and many dorsally; the two valves of the pair are joined one to the other by a distinct, elongate, chitinized connection present on the dorsal edge of the basal area.

Idiocerus ramentosus (Uhler).

(Pl XXV, fig. 4.)

Length, 1.96 mm.; greatest width, 0.17 mm. About the same width for entire length; only slightly curved, tip greatly narrowed with extreme apex rounded, moderately heavy chitinization, strengthening rod extends caudad as far as eleventh dorsal tooth. Toothed area on dorsal edge occupies a little more than the apical third; teeth eighteen in number, large, rounded, generally regular with a few double teeth, evenly spaced but farther apart basally; bear no secondary teeth: the tip bears three to four small, inconspicuous teeth along its ventral edge; area of ducts conspicuous, granular in appearance, circular duct openings visible; two to three open ventrally, three apically, and many dorsally; the two halves of the pair joined one to the other by an elongate, narrow, chitinized connection present on the dorsal edge of the basal area.

Idiocerus snowi Gillette and Baker.

(Pl. XXV, fig. 3.)

Length, 2.33 mm.; greatest width, 0.22 mm. About the same width for entire length; slightly curved, tip very bluntly rounded, rather heavily chitinized; strengthening rod extends caudad as far as eighth dorsal tooth. Toothed area on dorsal edge occupies the apical fourth; teeth ten in number,

medium in size, broad and rounded, regularly spaced except basally, where they are farther apart; bear no secondary teeth; no teeth present at the apex, area of ducts conspicuous, granular in appearance, circular duct openings visible, none open ventrally, six apically, and many dorsally; the two valves of the pair are joined one to the other by an elongate, narrow, chitinized connection present on the dorsal edge of the basal area.

Genus MACROPSIS Lewis.

The ovipositors of two species of this genus have been examined and found to be very similar. They are long, narrow and rodlike, about the same width for entire length, slightly curved, and narrow only at the apex to an obtuse point. The two valves of the pair are not identical as to length, shape of tip, and teeth found at tip. The toothed area occupies only a small part of the length at the apex. The teeth are few in number, rather large, rounded, and may or may not bear secondary teeth. The tip is notched with small teeth in both species. The ducts are elongate, conspicuous, few in number, and located only apically.

Macropsis viridis (Fitch).

(Pl. XXVI, fig. 1.)

Length, 2.3 mm.; greatest width, 0.05 mm. Very long, narrow, rodlike, about the same width for entire length, the two valves of the pair are not identical in length, shape of tip, and teeth found at tip; slightly curved, narrows at apex to obtuse point, rather heavily chitinized, strengthening rod extends caudad as far as second dorsal tooth. Toothed area occupies but a small portion at the apex, the longer valve bears two large teeth on its dorsal edge and eleven small, inconspicuous teeth along its ventral edge, the shorter valve bears three large teeth along its dorsal edge and eleven small teeth along its ventral edge, none of these teeth bear secondary teeth; the extreme apex of the longer valve is entirely devoid of teeth, while the ventral teeth of the shorter valve extend to the apex, ducts are conspicuous, few in number, elongate, all opening apically, two to four openings visible.

Macropsis suturalis (Osborn and Ball).

(Pl. XXVI, fig. 2.)

Length, 2.1 mm.; greatest width, 0.05 mm. Very long, narrow, rodlike, about the same width for entire length; the two valves of the pair are not identical, but differ in length, shape of tip, and teeth at tip; slightly curved, narrows at tip to an obtuse point, chitinization moderately heavy, somewhat lighter than in *M. viridis;* strengthening rod extends caudad as far as fifth dorsal tooth. Toothed area includes only the apical portion; the longer valve bears on its dorsal edge two large, heavily chitinized teeth at the tip and three large, somewhat less heavily chitinized teeth back from the tip; on its ventral edge are seventeen small teeth which are continuous around the tip; the shorter valve bears three large, heavily chitinized teeth at the tip, three less heavily chitinized teeth back from the tip, both groups being

on the dorsal edge, and thirteen small teeth on the ventral and apical edges; the three large teeth at the apex of the shorter valve bear small secondary teeth; the ducts are conspicuous, few in number, all located at the apex, six to seven openings visible.

Oncopsis distinctus (Van Duzee).

(Pl. XXVI, fig. 3.)

Length, 1.5 mm.; greatest width, 0.08 mm. Long, narrow, rodlike, about the same width for entire length; the two valves of the pair are not identical, but differ in length, shape of tip, and teeth found at tip; slightly curved, narrow at apex to obtuse point, heavily chitinized; strengthening rod extends caudad as far as the second dorsal tooth. Toothed area on dorsal edge occupies only the apical portion of the valve; the longer valve bears two large, heavily chitinized teeth on the dorsal edge and fourteen small, inconspicuous teeth on the ventral edge, and the shorter valve bears two large, heavily chitinized teeth on the dorsal edge and fourteen small, inconspicuous teeth on its ventral and apical edges; none of the teeth bear secondary teeth; the ducts are conspicuous, elongate, few in number; five to six open apically, and others are scattered along the basal rod of the valve and open dorsally.

Genus BYTHOSCOPUS Germar.

The ovipositors of two species of this genus have been examined and found to be similar. They are about the same width for the entire length; slightly though distinctly curved, narrow abrutly near the apex, and end in a rounded extreme apex. The teeth on the dorsal edge occupy about a third of the apical length, are numerous, small, irregular, and bear no secondary teeth. There are teeth on the ventral edge of tip in both species. The ducts are conspicuous, elongate, rather few in number. In both species there is present on the dorsal edge about midway of the valve an elongate, distinct, heavily chitinized connection between the two valves of the pair.

Bythoscopus apicalis (Osborn and Ball).

(Pl. XXV, fig 10.)

Length, 1.53 mm.; greatest width, 0.14 mm. The apical portion is slightly wider than the basal portion, distinctly curved; the valve narrows from a point about six-sevenths of its entire length to the tip, extreme apex rounded, chitinization moderately heavy; strengthening rod extends caudad to within six dorsal teeth from the apex. Toothed area on the dorsal edge occupies a little more than the apical third of the length; teeth numerous, very small and inconspicuous, flatly rounded, irregular in shape and size, unevenly spaced; bear no secondary teeth; the ventral edge of the tip bears a few inconspicuous teeth; ducts conspicuous, comparatively few in number, one group opens apically, and another group along the basal rod of the valve about midway; the two valves of the pair are joined one to the other by a distinct, elongate, chitinized connection present on the dorsal edge about midway of the valve, this connection bearing an angular tooth near its caudal extremity.

Bythoscopus miscellus (Stal).

(Pl. XXV, fig. 11.)

Length, 1.27 mm.; greatest width, 0.08 mm. About the same width for entire length; distinctly curved, tip narrowed abruptly from a slight prominence on the dorsal edge about eight-ninths of the length to a broadly rounded extreme apex; chitinization medium heavy, somewhat lighter than in *B. apicalis;* strengthening rod extends caudad as far as fourteenth dorsal tooth from the apex Toothed area on dorsal edge occupies a little less than the apical third; teeth numerous, small, rather sharply pointed, irregular, unevenly spaced; bear no secondary teeth; the tip is notched with teeth which are continuous around the tip, ten to eleven on the ventral edge; ducts conspicuous, elongate, few in number; one group opens apically, another at the basal end of the toothed area, and another in the basal rod about midway; the two valves of the pair are joined one to the other by a distinct, elongate, chitinized connection present on the dorsal edge about midway.

SUBFAMILY CICADELLINÆ Van Duzee.

Genus ONCOMETOPIA Stal.

The ovipositors of two species of this genus have been examined and found to be similar, though having some very distinct differences. The ovipositor of *O. undata* more closely resembles the ovipositor of *Homalodisca triquetra* than it does the ovipositor of *O. lateralis*. In the ovipositors of this genus we find a narrow, curved, rodlike basal attachment, and a broad, flat, apical shaft bearing teeth along its dorsal edge, and a preapical prominence on its ventral edge. The primary teeth in each case bear secondary teeth. The tip is notched with small teeth on both edges; the ducts are conspicuous, elongate, numerous, and distinctly curved.

Oncometopia undata (Fabricius).

(Pl. XXII, fig 3; pl. XXVI, fig 4)

Length of toothed area, 1.8 mm.; greatest width, 0.27 mm. Narrow and rodlike at base, widens beyond base into flat, broad apical shaft, which is about the same width for entire length and tapers only at the apex; preapical prominence present, conspicuous, broadly rounded; apical shaft slightly curved, tip broadly rounded, chitinization medium; strengthening rod extends caudad as far as last dorsal tooth. Toothed area on dorsal edge occupies entire length of broadened shaft; teeth thirty-one to thirty-two in number, of medium size, of a general triangular shape with the caudal side much longer than the cephalic side; apices rounded, regular, evenly spaced, more heavily chitinized than the rest of the valve; possess secondary teeth on both caudal and cephalic edges, one to four on cephalic edge and two to five on caudal edge, those on the caudal edge much larger than those on the cephalic edge; tip notched with small teeth on both dorsal and ventral edges, not continuous around the tip, fifteen teeth present on ventral edge between preapical

prominence and extreme apex; ducts conspicuous, decidedly curved, numerous, most numerous apically; open apically and along dorsal edge in and near teeth, one to three to each tooth.

Oncometopia lateralis (Fabricius).

(Pl XXII, fig. 4; pl. XXVI, fig. 5.)

Length 1.66 mm.; greatest width, 0.2 mm. Narrow and rodlike at the base, widens beyond base into broad, flat apical shaft, which tapers very slightly toward apex; preapical prominence present, rather indistinct, broadly rounded; only very slightly curved beyond the base, tip broadly rounded, chitinization medium, strengthening rod extends caudad as far as last dorsal tooth. Toothed area on dorsal edge occupies the entire length of the apical shaft; teeth eighteen to twenty in number, large, subquadrate in shape with the cephalic side longer than the caudal and bearing a smoothly rounded prominence, regular, evenly spaced, more heavily chitinized than the rest of the valve and have the appearance of being set into the rest of the valve; bear secondary teeth, seven to fifteen on the broad outer edge and four to eight on the cephalic side, those on the outer edge larger than those on the cephalic side; the tip is notched with small teeth on both dorsal and ventral edges, not continuous around the tip, twenty-one teeth between preapical prominence and extreme apex; ducts conspicuous, elongate, distinctly curved, numerous, most numerous apically; open apically, along the dorsal edge in and near teeth, two to four to each tooth; first three teeth not served with ducts.

Homalodisca triquetra (Fabricius).

(Pl XXII, fig 5, pl XXVI, fig 6)

Length, 2.6 mm ; greatest width, 0.33 mm. Narrow and rodlike at base, widens beyond base into broad, flat portion, which is about the same width for entire length, narrowing only at apex; preapical prominence present, distinct, broadly rounded; uncurved beyond base, extreme apex broadly rounded, chitinization medium; strengthening rod extends caudad as far as third dorsal tooth from the apex. Toothed area on dorsal edge occupies the entire length of the apical shaft; teeth forty-four to forty-five in number, medium in size, of a general triangular shape with the caudal side longer than the cephalic, regular in size and shape, evenly spaced, more heavily chitinized than the rest of the valve; bear secondary teeth, three to seven on the cephalic edge and five to nine on the caudal edge; those on the caudal edge are larger than those on the cephalic edge; tip notched with small teeth on both dorsal and ventral edges, not continuous around the tip, ducts conspicuous, numerous, slightly curved, most numerous apically; open apically along the dorsal edge in and near teeth, two to five to each tooth; the first six teeth not served by ducts.

Aulacizes irrorata (Fabricius).

(Pl. XXII, fig. 6; pl. XXVI, fig. 7.)

Length, 2.9 mm.; greatest width, 0.44 mm. Narrow and rodlike at the base, widens beyond base into broad, flat, apical shaft; reaches point of greatest width about two-fifths of length and from that point tapers gradually to the tip; preapical prominence present, conspicuous, obtuse-angled; not curved

beyond curved basal attachment; tip bluntly rounded, chitinization medium; strengthening rod extends caudad as far as third dorsal tooth from apex. Toothed area on dorsal edge occupies the entire length of the apical shaft; teeth forty-one to forty-three in number, rather small, in the shape of a flattened isosceles triangle, regular in size and shape, evenly spaced; the first twelve teeth bear no secondary teeth; the teeth caudad of the first twelve teeth bear four to ten secondary teeth on the caudal side; tip notched with small teeth on both dorsal and ventral edges, not continuous around the tip; thirty-five to thirty-seven teeth on ventral edge between preapical prominence and extreme apex; ducts conspicuous, elongate, rather narrow, curving, numerous, most numerous apically; open apically, along dorsal edge, near but not in teeth, and in face of valve back from edge; the first twelve teeth are not served by ducts.

Genus CICADELLA Latreille.

The ovipositors of two species of this genus have been examined and found to be similar. In each case the ovipositor consists of a narrow, curved basal attachment and a wider apical shaft which bears teeth along its dorsal edge, in turn bearing secondary teeth. A preapical prominence is present in one species, absent in the other. The tip is notched on both dorsal and ventral edges. The ducts are rather inconspicuous, elongate, rather few in number, and distinctly curved.

Cicadella hieroglyphica (Say).

(Pl. XXII, fig. 7, pl. XXVI, fig. 9.)

Length, 1.66 mm.; greatest width, 0.13 mm. Curved basal attachment narrow and rodlike; apical portion consists of a broad, flat shaft, about the same width for entire length, tapering only at apex, preapical prominence present on the ventral edge, obtuse-angled; only slightly curved; apex greatly narrowed and acutely pointed, very lightly chitinized; strengthening rod extends caudad as far as last dorsal tooth. Toothed area on dorsal edge occupies the entire length of the apical shaft; teeth seventeen to eighteen in number, medium in size, somewhat triangular with the apex flattened and the caudal side slightly longer than the cephalic, regular in size and shape, evenly spaced, more heavily chitinized than the rest of the valve; bear a large number of small, irregular, secondary teeth on both edges; tip notched with small teeth on both edges; a large number of very small teeth occur between the tip of the preapical prominence and the extreme apex; ducts rather inconspicuous, few in number greatly curved; open apically, along dorsal edge in and near teeth, and a few in the face of the valve back from the edge.

Cicadella circellata (Baker).

(Pl. XXII, fig. 8; pl. XXVI, fig 8.)

Length, 1.6 mm.; greatest width, 0.09 mm. Apical, flattened portion only slightly wider than basal portion; preapical prominence wanting; only slightly curved, tip greatly narrowed but rounded at extreme apex, chitinization rather light but heavier than in *C. hieroglyphica*; strengthening rod extends caudad as far as and beyond last dorsal tooth. Toothed area on dorsal edge

occupies nearly all of broadened area or about half the total length; teeth thirteen in number, rather small, in the general shape of a greatly flattened obtuse triangle with the caudal side much longer than the cephalic, regular in spacing; bear secondary teeth on both edges, five to eight on caudal edge and one to two on cephalic edge, those on the caudal edge are much the larger; tip notched with small teeth on both dorsal and ventral edges, not continuous around the tip, twenty present on ventral edge; ducts rather inconspicuous, though more conspicuous than in *C. hieroglyphica*, elongate, few in number, distinctly curved; open apically, along dorsal edge in and near teeth, and in face of valve back from edge.

Genus KOLLA Distant.

The ovipositors of three species of this genus have been examined and found to be similar. In each case the ovipositor consists of a curved, narrow, rodlike basal attachment and a broader, flat, apical shaft bearing teeth along its dorsal edge. The teeth are triangular in shape and bear small secondary teeth along their caudal sides. The tip is notched in each case with small teeth present on both edges, but not continuous around the tip. The ducts may or may not be visible; when visible they are elongate, rather straight, and few in number.

Kolla bifida (Say).

(Pl. XXII, fig. 13; pl. XXVIII, fig. 3.)

Length, 1.5 mm.; greatest width, 0.22 mm. Basal connection narrow and rodlike; apical shaft broad, flat, narrowing gradually to the apex; no preapical prominence; only very slightly curved beyond curved basal attachment; apex narrowed with extreme apex rounded, only lightly chitinized; strengthening rod extends caudad as far as and beyond last apical tooth. Toothed area on dorsal edge occupies entire length of apical shaft and more than two-thirds of the entire length; teeth fourteen in number, medium in size, in the general shape of a greatly flattened obtuse triangle with the caudal edge much longer than the cephalic and the apex rounded, not distinctly more heavily chitinized than the rest of the valve; bear small secondary teeth along the caudal edge only, seven to twenty-one on each tooth; the tip is notched with small teeth on both dorsal and ventral edges, not continuous around the tip, fourteen to fifteen on ventral edge; ducts inconspicuous, only apices and circular openings visible; open apically, along the dorsal edge in and near teeth, and a few in the face of the valve back from the edge.

Kolla geometrica (Signoret).

(Pl. XXVIII, fig. 2.)

Length, 1.17 mm.; greatest width, 0.17 mm. Basal portion narrow and rodlike; apical shaft broad, flat, tapers to apex; no preapical prominence; not curved beyond base; tip greatly narrowed with extreme apex rounded bluntly; chitinization light though somewhat heavier than in *K. bifida*; strengthening rod extends caudad as far as last dorsal tooth. Toothed area on dorsal edge occupies entire length of broadened shaft; teeth seventeen to nineteen in

number, rather small, in the general shape of a greatly flattened obtuse triangle with the caudal side much longer than the cephalic and the apex rounded, rather irregular in size and spacing, slightly more heavily chitinized than the rest of the valve; bear secondary teeth along the caudal edge only, four to fourteen on each tooth; tip notched with teeth on both dorsal and ventral edges, not continuous around the tip, thirteen to fifteen on ventral edge; ducts easily visible for entire length, comparatively few in number, straight, more numerous apically; open apically, along dorsal edge in and near teeth, and in the face of valve back from edge.

Kolla hartii (Ball).

(Pl. XXII, fig. 14; pl. XXVIII, fig. 1.)

Length, 1.4 mm.; greatest width, 0.22 mm. Basal portion narrow and rodlike; apical shaft broad and flat, tapers towards apex; no preapical prominence; not curved beyond base, tip greatly narrowed, extreme apex smoothly rounded, lightly chitinized; strengthening rod extends caudad beyond last dorsal tooth. Toothed area on dorsal edge occupies entire length of apical shaft; teeth seventeen in number, medium in size, in the shape of an obtuse triangle, though not so flat as in *K. bifida* and *K. geometrica;* caudal edge somewhat longer than cephalic edge, rather irregular in size and spacing, not more heavily chitinized than the rest of the valve; possess small secondary teeth on the caudal edge of each primary tooth, eight to seventeen to each tooth; tip notched with small teeth on both dorsal and ventral edges, not continuous around tip, twenty-three on ventral edge; ducts more conspicuous than in *K. bifida,* less conspicuous than in *K. geometrica;* bases and apices visible but middle portions invisible; open apically, along dorsal edge in and near teeth, and in face of valve back from edge.

Helochara communis Fitch.

(Pl. XXII, fig. 10; pl. XXVII, fig. 5.)

Length, 1.44 mm.; greatest width, 0.22 mm. Basal portion narrow and curved, apical shaft broad and flat, about the same width for entire length, tapers toward tip; bears no preapical prominence; not curved beyond the base, tip greatly narrowed, with the extreme apex ending in an obtuse point, chitinization medium; strengthening rod extends caudad to a point midway between the last dorsal tooth and the tip. Toothed area on dorsal edge occupies the entire length of the apical shaft, nearly the entire length of the valve; teeth thirty in number, rather large, the first fourteen of a general triangular shape, apical sixteen subquadrate with the cephalic side longer than the caudal, rather irregular in size, shape, and spacing; basal fourteen primary teeth bear small secondary teeth on the two exposed sides of the triangle; apical sixteen primary teeth also bear secondary teeth on the outer margin, three to fourteen in number; tip is notched with small teeth on both dorsal and ventral edges, not continuous around the tip, forty-six present on ventral edge; ducts conspicuous, rather numerous, elongate, rather straight, occupy entire shaft; open apically, along dorsal edge in and near teeth, and in face of valve back from edge.

Graphocephala coccinea (Forster).

(Pl. XXII, fig. 9; pl. XXVIII, fig. 4.)

Length, 1.87 mm.; greatest width, 0.22 mm. Basal portion narrow and rodlike, apical shaft broad and flat, about the same width for entire length; preapical prominence present, distinct, obtuse-angled; not curved beyond base, tip greatly narrowed and ending in a rather blunt point, chitinization light; strengthening rod extends caudad beyond last dorsal tooth. Toothed area on dorsal edge occupies entire length of apical shaft; teeth nineteen in number, medium in size, of a general triangular shape with the caudal side longer than the cephalic, regular in size and shape, distinctly more heavily chitinized than the rest of the valve; bear small secondary teeth on both edges, three to six on cephalic edge and eight to seventeen on caudal edge; tip notched with small teeth on both dorsal and ventral edges, not continuous around the tip, forty-five between preapical prominence and extreme apex; ducts easily visible though not conspicuous, elongate, rather few in number, curved, most numerous apically; open apically, along dorsal edge in teeth, one to two to each tooth, and a few in the face of valve back from edge

Genus DRÆCULACEPHALA Ball.

The ovipositors of three species of this genus have been examined and found to be similar. The ovipositor of *Helochara communis* also shows its close relationship to this genus. In each case the ovipositor consists of a curved, rodlike basal attachment and a broad, flat, apical shaft which bears teeth along its dorsal edge for the entire length. The distal teeth are triangular and the apical teeth subquadrate. Both types of teeth bear small secondary teeth. The tip in every case is notched with small teeth on both dorsal and ventral edges, not continuous around the tip. The ducts may or may not be conspicuous, but where visible are elongate, numerous and curved.

Dræculacephala mollipes (Say).

(Pl. XXII, fig. 11; pl XXVII, fig. 2)

Length, 2.1 mm.; greatest width, 0.33 mm. Basal portion narrow and rodlike, apical shaft broad and flat, about the same width for entire length, narrowing caudad to apex; preapical prominence wanting; not curved beyond base, tip greatly narrowed by curving ventral edge and ends in an obtuse point, chitinization moderately heavy; strengthening rod extends caudad to a point midway between last dorsal tooth and apex. Toothed area on dorsal edge occupies entire length on apical shaft; teeth twenty-eight in number, large, basal nine of a general triangular shape, apical nineteen subquadrate with the cephalic side longer than the caudal, rather irregular in size, shape and spacing; the basal nine bear small secondary teeth on both cephalic and caudal edges; the apical subquadrate teeth also bear secondary teeth, seven to seventeen on the outer edge and all except the apical five bear secondary teeth along the cephalic edge, one to six in number; tip is notched with small teeth on both dorsal and ventral edges, not continuous around the tip, forty-

two on the ventral edge; ducts conspicuous, rather numerous, elongate, slightly curved, most numerous apically; open apically, along dorsal edge in and near teeth, and in the surface of the valve back from edge.

Draeculacephala noveboracensis (Fitch).

(Pl. XXVII, fig. 1.)

Length, 2.65 mm; greatest width, 0.33 mm. Narrow and rodlike at base, broad and flat apically, apical shaft about the same width for entire length; preapical prominence wanting; only slightly curved beyond base, tip greatly narrowed by slightly curving dorsal edge and greatly curving ventral edge and ends in a rather sharp point, chitinization light, much lighter than in the other members of this genus examined; strengthening rod extends caudad to a point midway between last dorsal tooth and apex. Toothed area on dorsal edge occupies entire length of apical shaft, the dorsal edge bearing the teeth more heavily chitinized than the rest of the valve; teeth thirty-nine to forty-one in number, of medium size, the basal sixteen of a general triangular shape, the apical twenty-three subquadrate with the cephalic side longer than the caudal, rather irregular in size, shape, and spacing; the basal triangular teeth bear small secondary teeth on both dorsal and ventral edges; the apical subquadrate teeth bear three to twelve secondary teeth on the outer edge and two to five on the cephalic edge; the secondary teeth midway of the valve are very small and indistinct; tip notched with small teeth on both dorsal and ventral edges, not continuous around the tip, forty-five present on the ventral edge; ducts inconspicuous, very faintly visible except at openings, rather numerous, most numerous apically; open apically, along dorsal edge in and near teeth, and in surface of valve back from edge.

Draeculacephala reticulata (Signoret)

(Pl XXII, fig. 12; pl XXVII, fig. 3.)

Length, 1.75 mm.; greatest width, 0.27 mm. Basal portion narrow and rodlike, apical portion broad, flat, about the same width for entire length, narrows at apex; preapical prominence wanting; not curved beyond curved basal attachment, tip greatly narrowed by slightly curved dorsal edge and greatly curved ventral edge, ends in obtuse point, chitinization medium, less heavy than in *D. noveboracensis* and heavier than in *D. mollipes*; strengthening rod extends caudad to a point midway between last dorsal tooth and apex. Toothed area on dorsal edge occupies apical shaft for entire length; teeth twenty-six to twenty-eight in number, rather large, basal eleven of a general triangular shape, apical fifteen subquadrate with the cephalic side longer than the caudal, rather irregular in size, shape and spacing; basal eleven bear small secondary teeth on both edges; apical subquadrate teeth also bear secondary teeth, three to eleven on the outer edge and, with the exception of the apical three, one to five on the cephalic edge; tip notched with small teeth on both dorsal and ventral edges, not continuous around the tip, 42 present on the ventral edge; ducts conspicuous, rather straight, numerous, most numerous apically; open apically, along dorsal edge in and near teeth, and a few in the face of valve back from edge.

Pagaronia tripunctata (Fitch).

(Pl. XXVII, fig. 6.)

Length, 1.5 mm.; greatest width, 0.17 mm. Narrow and rodlike at base, apical shaft broad and flat, about the same width for entire length, narrows caudad to apex; preapical prominence wanting; not curved beyond base, tip narrowed, bluntly rounded at extreme apex, chitinization light; strengthening rod extends caudad as far as last dorsal tooth. Toothed area on dorsal edge occupies entire length of apical shaft, dorsal edge bearing teeth is more heavily chitinized than the rest of the valve; teeth seventeen to twenty in number, medium in size, in the shape of a flattened obtuse triangle with the caudal side much longer than the cephalic, irregular in size, shape and spacing; bear secondary teeth on both outer edges, three to ten on cephalic edge and three to twenty-five on the caudal edge; tip notched with small teeth on both dorsal and ventral edges, not continuous around the tip, 30 present on ventral edge; ducts conspicuous, rather numerous, only slightly curved, most numerous apically; open apically, along dorsal edge in and near teeth, and a few in the surface of valve back from edge.

Errhomenellus montanus Baker.

(Pl. XXVII, fig. 4.)

Length, 2.83 mm.; greatest width, 0.22 mm. About the same width for entire length; preapical prominence present, rather indistinct, broadly rounded; only slightly curved beyond curved basal attachment, tip greatly narrowed with the extreme apex rounded, chitinization medium; strengthening rod extends caudad as far as fourth dorsal tooth. Toothed area on dorsal edge occupies less than a fourth of the entire length apically; teeth seven to eight in number, small, inconspicuous, rounded, regular in size and shape, rather far apart, uneven in spacing, bear no secondary teeth; tip bears no teeth; no distinct ducts visible, circular openings plainly visible, of these a number occur on the ventral apical edge, some at the extreme apex, and also along the entire dorsal edge.

SUBFAMILY GYPONINÆ (Stal).

Genus GYPONA Germar.

The ovipositors of four species of this genus have been examined and found to be similar. The ovipositor of *Xerophlœa viridis*, the only other species of this subfamily examined, is not similar to the ovipositors of the genus Gypona. In this genus the ovipositor is relatively short, stout and broad, usually being rather heavily chitinized. The apical portion is not much, if any, wider than the basal portion. Teeth are present along the dorsal edge for from one-fourth to one-half the apical length. The tip may or may not bear teeth on one or both edges. The ducts in every case are conspicuous, large, elongate and numerous.

Gypona octo-lineata (Say).

(Pl. XXIII, fig. 1; pl. XXVIII, fig. 8.)

Length, 2 mm.; greatest width, 0.48 mm. Consists of a rather narrow basal portion, which widens out into a broad, apical portion, which narrows caudad to the apex, point of greatest width about midway; no preapical prominence; slightly curved, tip greatly narrowed with the extreme apex broadly rounded, chitinization moderately heavy; strengthening rod extends caudad almost to apex. Toothed area on dorsal edge occupies about a half of the apical length; teeth numerous, rather small, rounded, irregular in size, shape and spacing; bear no secondary teeth; tip bears small teeth on both dorsal and ventral edges, not continuous around the tip, thirteen on ventral edge; ducts conspicuous, large, numerous, apparently arising from a common cavity in the center of the valve, most numerous at the tip; open along ventral apical edge, at extreme apex, and along the dorsal edge for the entire length, though very few in basal region.

Gypona bimaculata Spangberg.

(Pl. XXVIII, fig. 5.)

Length, 3.17 mm.; greatest width, 0.42 mm. About the same width for entire length, bears a broadly rounded, heavily chitinized prominence on the dorsal edge somewhat less than midway of the length, tapers caudad toward apex; slightly curved, tip gradually narrowed, ending in a blunt point, chitinization heavy, much heavier than in *G. octo-lineata;* strengthening rod extends caudad almost to apex. Toothed area on dorsal edge occupies about one-third of apical length; teeth numerous, rather small, rounding, irregular in size and shape; bear no secondary teeth; tip notched on dorsal edge and at extreme apex with small teeth, none present on ventral edge; ducts conspicuous, very large, rather straight; open apically and along dorsal and ventral edges for the length of the toothed area, a few also open in the basal region.

Gypona angulata Spangberg.

(Pl. XXVIII, fig. 6.)

Length, 1.75 mm.; greatest width, 0.35 mm. Apical portion somewhat wider than basal, point of greatest width about midway, tapers caudad to apex; only slightly curved, tip gradually narrowed with the extreme apex rounded, chitinization moderately heavy; strengthening rod extends caudad to within a short distance of tip. Toothed area extends from the prominence on the dorsal edge to the apex; teeth numerous, small and indistinct, rather flatly rounded, very irregular in size, shape and spacing; bear no secondary teeth; no teeth on tip; ducts conspicuous, large, numerous, broadly curving, most numerous apically; open apically, along ventral apical edge, along dorsal edge of toothed area, and a few in the basal portion of the valve.

Gypona pectoralis Spangberg.

(Pl. XXVIII, fig. 7.)

Length, 1.83 mm.; greatest width, 0.42 mm. Very broad and heavy for entire length, point of greatest width about midway, where there is a broadly rounded prominence on the dorsal edge, narrows caudad to apex; slightly curved, tip greatly narrowed with extreme apex rounded, chitinization very

heavy; strengthening rod extends caudad almost to apex. Toothed area on dorsal edge occupies about a fourth of the apical length; teeth very few in number, small, flat, somewhat rounded, very irregular in size, shape and spacing, bear no secondary teeth; no teeth present at extreme apex; ducts conspicuous, large, somewhat branching, more numerous apically; open apically, along ventral apical edge, and along dorsal for entire length.

Xerophlœa viridis (Fabricius).

(Pl. XXIII, fig. 2; Pl. XXIX, fig 2.)

Length, 2.88 mm.; greatest width, 0.08 mm. Narrow and rodlike, about the same width for entire length; distinctly curved, tip bluntly rounded, chitinization medium; strengthening rod extends caudad as far as twentieth dorsal tooth. Toothed area on dorsal edge occupies a little less than the apical third; teeth twenty-four in number, medium in size, rounded, regular in size and shape, the apical four are farther apart than the basal twenty; the apical three bear one to three secondary teeth on the caudal edge; tip notched with small teeth on both dorsal and ventral edge, not continuous around the tip, twelve to thirteen on ventral edge; ducts conspicuous, relatively few in number, most numerous at apex; open apically and along entire dorsal edge, even in basal portion.

SUBFAMILY JASSINÆ (Amyot and Serville).

TRIBE ACUCEPHALINI (Dohrn).

Stroggylocephalus agrestis (Fallen).

(Pl XXIX, fig 3)

Length, 1.88 mm.; greatest width, 0.17 mm. Curved base rather narrow and rodlike, rather broad and flat beyond base, about the same width for entire length, tapers gradually toward apex; curved at base of broadened area, tip greatly narrowed with extreme apex narrowly rounded, chitinization rather light, strengthening rod extends caudad as far as sixth dorsal tooth from apex. Toothed area on dorsal edge occupies a little less than half the entire length, teeth twenty-six to twenty-eight in number, rather small, of a general triangular shape, some rounded and some sharply pointed, very irregular in size, shape and spacing; bear no secondary teeth; tip notched with a few small, indistinct, irregular teeth on the ventral edge only; ducts conspicuous, elongate; open along ventral apical edge, at extreme apex, and along entire dorsal edge; the two valves of the pair are joined one to the other by a distinct, elongate, heavily chitinized connection present on the dorsal edge near the base of the broadened area.

Memnonia consobrina Ball.

(Pl. XXIX, fig. 5)

Length, 2.2 mm.; greatest width, 0.25 mm. Curved basal attachment narrow and rodlike, beyond base is a rather narrow, lightly chitinized area extending caudad for about a third of the length; caudad of this is a broader, more heavily chitinized portion occupying the rest of the valve; narrows rather abruptly caudad to apex; only slightly curved beyond base, tip greatly narrowed by broadly curving dorsal edge; extreme apex ends in sharp, acute-

angled point, chitinization moderately light; strengthening rod extends caudad almost to apex. There are no evidences of distinct teeth, though the margin is irregularly roughened in several places; area of ducts conspicuous, granular in appearance, circular duct openings visible; open along ventral apical edge, at extreme apex, and along dorsal edge for entire length.

Xestocephalus pulicarius Van Duzee.

(Pl XXIII, fig 8; pl. XXIX, fig 1.)

Length, 0.88 mm.; greatest width, 0.08 mm. Curved basal attachment narrow and rodlike, rest of valve about the same width for entire length; preapical prominence on ventral edge present, distinct, obtuse angled, giving the apical portion of the valve the appearance of a spear head; tip narrowed abruptly beyond preapical prominence; very distinctly, broadly and evenly curved; tip greatly narrowed, ending in sharply pointed extreme apex, chitinization medium; strengthening rod extends caudad to within a short distance of extreme apex; dorsal edge of tip bears an indistinct notch where rod meets dorsal edge. Toothed area on dorsal edge occupies the apical three-fourths of the length; teeth fourteen to fifteen in number, small, indistinct, rather irregular in size, shape and spacing, especially basally; bear no secondary teeth; tip bears no teeth, ducts rather inconspicuous though plainly visible, rather few; open in preapical prominence, at extreme apex, and along entire dorsal edge; the two valves of the pair are joined one to the other by a distinct, elongate, narrow, heavily chitinized connection present on the dorsal edge, this connection more liberally supplied with ducts than the portion of the valve immediately caudad of it.

TRIBE JASSINI (Dohrn).

Dorycephalus platyrhynchus Osborn.

(Pl XXIX, fig. 4)

Length, 3.5 mm.; greatest width, 0.5 mm. Curved basal portion narrow and rodlike; at a point about a third of the length it widens into a broad, flat shaft which tapers slightly caudad; point of greatest width is a little less then midway; only slightly curved beyond base, tip greatly narrowed by rounding dorsal edge, extreme apex rounded, chitinization very light; strengthening rod extends caudad to within a short distance of the extreme apex. There are no distinct teeth, though the ventral apical edge and the entire dorsal edge are slightly and irregularly roughened; area of ducts inconspicuous, no ducts visible, circular duct openings visible; a single row opens along the ventral apical edge, a single row along the dorsal apical edge, distad of these a double row, distad of the double row a triple row, and still further distad in the wider portion of the valve as many as four or five irregular rows open in the entire breadth of the valve.

Hecalus lineatus (Uhler).

(Pl. XXIX, fig. 8)

Lenth, 4.1 mm.; greatest width, 0.43 mm. Curved basal portion narrow and rodlike, widens beyond base into broad, flat portion which tapers gradually caudad to apex, point of greatest width about two-fifths of length; only slightly curved beyond base, tip greatly narrowed, ending in sharp point, chitinization

moderately light; strengthening rod extends caudad to within a short distance of the apex. No distinct teeth present, the ventral apical edge and the entire dorsal edge except at the apex are slightly and irregularly roughened; area of ducts conspicuous, granular in appearance, circular duct openings visible; open along ventral apical edge and along dorsal edge for entire length, in the basal region they open irregularly in the entire width of the valve.

Spangbergiella mexicana Baker.

(Pl. XXIX, fig. 6.)

Length, 1.9 mm., greatest width, 0.27 mm. Curved base narrow and rodlike, widens into broad, flat portion, about the same width for entire length, narrowing caudad to apex; bears two prominences, one on dorsal edge somewhat less than midway, and the other on the ventral edge about two-thirds the length, more angular; not curved beyond the base, narrowed at tip evenly and gradually by both curving edges, ends in sharp point, chitinization medium; strengthening rod extends caudad almost to apex. Bears no teeth; area of ducts granular in appearance, circular openings very small and inconspicuous; open along ventral apical edge, at extreme apex, along dorsal edge, and in basal portion of valve.

Parabolocratus flavidus Signoret.

(Pl. XXIX, fig. 7.)

Length, 2.3 mm.; greatest width, 0.27 mm. Curved base narrow and rodlike, widens gradually into broad, flat portion, about the same width for entire length, narrowing only at apex; bears two broadly rounded prominences, one on the dorsal edge about a third of the length, the other on the ventral edge about two-thirds the length; only slightly curved beyond base, tip gradually narrowed and ends in sharp point, chitinization medium; strengthening rod extends caudad to within a short distance of the apex. Toothed only at extreme tip; teeth are continuous around the tip, of these six are on the dorsal edge and ten on the ventral edge; ducts inconspicuous, invisible except at extreme apices, circular openings visible; open along ventral apical edge and along entire dorsal edge except in dorsal prominence.

Aligia jucunda (Uhler).

(Pl. XXIX, fig. 11.)

Length, 1.83 mm.; greatest width, 0.17 mm. Curved base narrow and rodlike, slightly wider beyond base for a little more than half the length; apical portion of valve widens abruptly, tapers caudad to apex; distinctly curved, tip narrowed by curved dorsal edge, extreme apex bluntly rounded, almost square, chitinization medium; strengthening rod extends caudad to within fourteen dorsal teeth of apex. Toothed area on dorsal edge occupies somewhat less than the apical half; teeth eighty-eight in number, very small, wedge-shaped, fairly regular in size, shape and spacing, bear small secondary teeth on outer edge, one to four in number; tip devoid of teeth on ventral and caudal edges; area of ducts conspicuous, granular in appearance, though a few elongate ducts are visible apically; ducts straight, numerous; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and irregularly in the basal region. The two valves of the pair are joined one to the other by an elongate

connection only slightly more heavily chitinized than the rest of the valve, present on the dorsal edge in the basal region.

Genus MESAMIA Ball.

Two species of this genus have been examined and found to be similar. In each case the ovipositor consists of a curved basal attachment, a somewhat wider portion that extends about to the midpoint, and an apical portion which bears teeth along its dorsal edge. A small preapical prominence is present on one of the two species. Some of the primary teeth, at least, bear secondary teeth. In one species the tip bears distinct teeth, in the other the tip is only irregularly roughened. The area of ducts is granular in appearance and the duct openings are visible. The two valves of the pair are joined one to the other by an elongate, heavily chitinized connection present on the dorsal edge in the basal region.

Mesamia straminea (Osborn).

(Pl. XXIX, fig. 9.)

Length, 1.53 mm.; greatest width, 0.18 mm. Curved basal portion narrow and rodlike, beyond base is a wider, heavily chitinized area extending almost to the midpoint; the apical toothed area occupies the rest of the valve and is slightly wider, less heavily chitinized, and tapers caudad to the apex; bears no preapical prominence; slightly, though distinctly curved, tip narrowly rounded, chitinization moderately heavy; strengthening rod extends caudad as far as fourth dorsal tooth from the tip. Toothed area on dorsal edge occupies the apical half; about twenty-five primary teeth present, of medium size, very irregular as to size, shape and spacing; the apical ten are somewhat regular, long and flatly rounded and may or may not bear a few secondary teeth on the caudal edge, the teeth distad of these extremely irregular; the tip is irregularly roughened on both dorsal and ventral edges, but bears no distinct teeth; area of ducts granular in appearance, duct openings easily visible; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and in the basal portion of the valve; the two valves of the pair are joined one to the other by a distinct, elongate, heavily chitinized connection present on the dorsal edge at about one-third the length; the apex is apparently strengthened by a straight, narrow rod that extends from the interior of the valve to the extreme apex, occupying about the apical sixth of the length.

Mesamia vitellina (Fitch).

(Pl. XXIII, fig. 7, pl. XXIX, fig. 10.)

Length, 1.47 mm.; greatest width, 0.13 mm. Curved basal connection narrow and rodlike, widens out into broader area, which is about the same width for entire length and toothed apically; a small preapical prominence is present on the ventral edge; distinctly curved, tip narrowed, narrowly rounded at extreme apex, chitinization moderately heavy; strengthening rod extends caudad as far as fifth dorsal tooth from apex. Toothed area on dorsal edge occupies a little less than the apical half; teeth seventeen in number, rather small, in

the general shape of a greatly flattened obtuse triangle with a rounded apex, fairly regular in size, shape and spacing, those distad being very flat and indistinct, bear small; numerous secondary teeth on both cephalic and caudal edges; tip notched with small teeth on both edges, not continuous around the tip, twelve to thirteen present between preapical prominence and apex, area of ducts granular in appearance, circular duct openings visible; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and in basal portion of the valve; the two valves of the pair are joined one to the other by an elongate, distinct, heavily chitinized connection present on the dorsal edge at a point a little more than one-third the length of the valve; the apex is apparently strengthened by a short, narrow rod which can be seen only at the extreme apex, much shorter and lighter than in *M. straminea*.

Genus SCAPHOIDEUS Uhler.

The ovipositors of two species of this genus have been examined. They do not resemble each other to the degree that is common between two species of the same genus, though they have many points in common. In each case the ovipositor is about the same width for the entire length, narrows only at the apex, and bears no preapical prominence. The dorsal edge bears teeth along the apical two-fifths of its length, but these teeth differ in number, size, shape, and possession of secondary teeth in the two species, the tip bears teeth in one species, none in the other; the area of ducts is granular in appearance and the duct openings are visible. The two valves of the pair are joined one to the other by an elongate, heavily chitinized connection present on the dorsal edge about midway of the valve.

Scaphoideus scalaris Van Duzee.

(Pl. XXX, fig. 1.)

Length, 1.53 mm.; greatest width, 0.13 mm. Curved basal connection narrow and rodlike, rest of valve about the same width for entire length, narrowing only at apex; bears no preapical prominence; slightly curved, tip narrowed, bluntly rounded at extreme apex, chitinization rather heavy; strengthening rod extends caudad almost to second dorsal tooth from apex. Toothed area on dorsal edge occupies a little more than the apical two-fifths of the length; teeth nine in number, rather large, broadly rounded, rather irregular in size, shape and spacing being farther apart basally; bear no secondary teeth; tip bears no teeth, ducts granular in appearance, circular duct openings visible; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and irregularly in the basal region where elongate ducts are visible; the two valves of the pair are joined one to the other by an elongate, heavily chitinized connection present on the dorsal edge about midway of the valve; this connection occupies a little less than a third of the entire length and bears the first dorsal tooth.

Scaphoideus immistus (Say).

(Pl XXIII, fig 4; pl. XXX, fig. 2)

Length, 1.77 mm.; greatest width, 0.11 mm. Narrow and rodlike at base, rest of valve somewhat broader, about the same width for entire length, narrows caudad to apex; bears no preapical prominence; distinctly curved, tip greatly narrowed, extreme apex rounded, chitinization moderately heavy; strengthening rod extends caudad as far as fifth dorsal tooth from apex Toothed area on dorsal edge occupies a little less than the apical two-fifths of the length; teeth sixteen in number, rather small, rounded, rather irregular in size, shape and spacing being farther apart basally; may bear secondary on one or both edges, small secondary teeth also present on margin of valve between primary teeth, general arrangement of secondary teeth very irregular; tip notched with small, irregular teeth on both edges, though more distinct on the ventral edge, not continuous around the tip, eight to nine present on the ventral edge; ducts partly granular and partly elongate, circular openings visible, open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and irregularly in the basal region; the two valves of the pair are joined one to the other by an elongate, heavily chitinized connection present on the dorsal edge about midway, occupies about two-fifths of length, bears one rounded tooth somewhat caudad of the center.

Genus PLATYMETOPIUS Burmeister.

The ovipositors of three members of this genus have been examined and found to be similar. In each case the basal half is slightly narrower than the apical half, which bears teeth along its dorsal edge. A preapical prominence may or may not be present. The primary teeth bear secondary teeth on both edges, more on the caudal than on the cephalic edge. In every case the tip is notched with small teeth on both dorsal and ventral edges; these may or may not be continuous around the tip. The area of ducts may or may not be conspicuous, when visible is granular in appearance with the duct openings visible. The two valves of the pair are joined one to the other by a rather short, chitinous connection present on the dorsal edge of the basal area.

Platymetopius acutus (Say).

(Pl XXIII, fig 5, pl XXX, fig 3)

Length, 1.36 mm, greatest width, 0.17 mm. Curved basal connection narrow and rodlike; beyond this is a somewhat wider portion extending nearly to midpoint, and apically the toothed area, about the same width for entire length, narrowing only at apex, bears an indistinct, broadly angled preapical prominence on the ventral edge; slightly though distinctly curved, tip narrowed and ending in a bluntly rounded extreme apex, chitinization light; strengthening rod extends caudad as far as fifth dorsal tooth from apex. Toothed area on dorsal edge occupies the apical half of the valve; teeth twenty-seven in number, rather large; in the greater number of teeth the basal

edges of each tooth are more or less parallel and the apical edges taper, giving a gabled appearance to the tooth; the caudal edge is somewhat longer than the cephalic, fairly regular as to size, shape and spacing, though not entirely so; primary teeth bear small secondary teeth on caudal edge more commonly, and a few teeth also bear secondary teeth on the cephalic edge; tip notched with small teeth on both dorsal and ventral edges, continuous around the tip, nineteen present on ventral edge between preapical prominence and apex; area of ducts inconspicuous, the apices and circular openings alone being visible; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and irregularly in the basal portion of the valve; the two valves of the pair are joined one to the other by an indistinct, chitinous connection present on the dorsal edge at about a third of the length.

Platymetopius cinereus Osborn.

(Pl. XXX, fig. 4.)

Length, 1.13 mm.; greatest width, 0.13 mm. Curved basal connection narrow and rodlike; a wider area extends almost to midpoint, a slighter wider apical portion occupies the rest of the valve; no preapical prominence; slightly curved, tip narrowed, ends in obtuse-angled point, chitinization moderately light; strengthening rod extends caudad as far as sixth dorsal tooth from apex. Toothed area on dorsal edge occupies a little more than the apical half; teeth twenty-three to twenty-four in number, moderately large, of a general triangular shape with the caudal side in most cases longer than the cephalic and with apices rounded, fairly regular in size, shape and spacing; bears small secondary teeth on caudal edge, three to eight in number, and a few of the teeth also bear a single secondary tooth on the cephalic edge; tip notched with small teeth on both dorsal and ventral edges, more numerous and distinct on ventral edge, not continuous around the tip, fourteen present on the ventral edge; ducts very inconspicuous, only a few being visible in the apex of the valve, apices of ducts and duct openings visible; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and irregularly in the basal portion of the valve; the two valves of the pair are joined one to the other by a poorly defined, heavily chitinized connection present on the dorsal edge at about one-third the length.

Platymetopius frontalis Van Duzee.

(Pl. XXIII, fig 6; pl. XXX, fig. 5.)

Length, 1.26 mm.; greatest width, 0.16 mm. Curved basal connection narrow and rodlike; a slightly wider portion extends to a point nearly midway; the apical portion is slightly wider, narrows caudad to apex, bears a suggestion of a broadly rounded preapical prominence on the ventral edge; slightly curved, tip narrowed, ends in a blunt, obtuse-angled point, chitinization moderately heavy, heavier than in *P. acutus* and *P. cinereus*; strengthening rod extends caudad as far as fifth dorsal tooth from apex. Toothed area on dorsal edge occupies a little more than the apical half; teeth twenty-one to twenty-two in number, rather large; in the greater number the basal edges of each tooth are parallel and the apical edges taper to a rounded apex, fairly regular in size, shape and spacing; bear small secondary teeth for the most part on the

caudal edge; tip notched with small teeth on both dorsal and ventral edges, practically continuous around the tip, eighteen present on the ventral edge; area of ducts conspicuous, granular in appearance, circular duct openings visible; open along ventral apical edge, along dorsal edge of toothed area, and irregularly in the basal area of the valve; the two valves of the pair are joined one to the other by a distinct, rectangular, heavily chitinized connection present on the dorsal edge at about one-third the length.

Genus DELTOCEPHALUS Burmeister.

The ovipositors of seven species of this genus have been examined and found to be similar. The ovipositor is slightly curved, gradually narrowed toward the apex, with apical half little if any wider than the basal half. The apical half bears teeth along its dorsal edge, usually small, rounded, and bearing a few secondary teeth. The apex may or may not bear small teeth on one or both edges. The area of ducts may or may not be conspicuous; when visible is granular in appearance with duct openings visible. The two valves of the pair are joined one to the other by a chitinous connection present on the dorsal edge of the basal area.

Deltocephalus reflexus Osborn and Ball.

(Pl. XXX, fig. 6.)

Length, 1.18 mm.; greatest width, 0.09 mm. About the same width for entire length; tapers gradually caudad to tip; no preapical prominence; slightly but distinctly curved, tip gradually narrowed, extreme apex sharply pointed, chitinization light; strengthening rod extends caudad as far as tenth dorsal tooth from tip, nearly meeting dorsal edge. Toothed area on dorsal edge occupies somewhat less than the apical half of the valve; teeth about forty in number, rather small, of various sizes and shapes, presenting an irregular, crenulate margin; a few of the larger teeth bear secondary teeth; the extreme tip bears no teeth; ducts inconspicuous, invisible except for apices and circular openings; open along ventral apical edge, along dorsal edge of toothed area, and irregularly in the basal portion of the valve; the two valves of the pair are joined one to the other by a poorly defined, rather elongate, heavily chitinized connection present on the dorsal edge a little past a third of the length.

Deltocephalus weedi Van Duzee.

(Pl. XXX, fig. 7.)

Length, 1.05 mm.; greatest width, 0.13 mm. Narrow and rodlike at base; a somewhat wider, rather heavily chitinized area extends almost to midpoint; the apical half is occupied by a still wider, less heavily chitinized area which tapers to apex; preapical prominence wanting; slightly curved, tip greatly narrowed, extreme apex rounded, chitinization moderately heavy; heavier than in *D. reflexus;* strengthening rod extends caudad as far as or beyond last dorsal tooth. Toothed area on dorsal edge occupies a little more than the apical half of the valve; about thirteen large primary teeth, these are comparatively

small, rounded, fairly regular in size, shape and spacing; bear a few small secondary teeth on caudal edge; margin of valve between teeth is also notched with small secondary teeth; tip notched with small teeth on both dorsal and ventral edges, not continuous around the tip, nine present on ventral edge; area of ducts conspicuous, granular in appearance, circular duct openings visible; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and irregularly in the basal area where elongate ducts are visible; the two valves of the pair are joined one to the other by an elongate, distinct, heavily chitinized connection present on the dorsal edge about a third of the length.

Deltocephalus inimicus (Say).

(Pl. XXIII, fig. 8; pl. XXX, fig. 8.)

Length, 1.1 mm.; greatest width, 0.11 mm. About the same width for entire length, narrows caudad to apex, preapical prominence wanting; slightly curved; tip greatly narrowed, extreme apex rounded, chitinization moderately heavy; strengthening rod extends caudad as far as last dorsal primary tooth. Toothed area on dorsal edge occupies apical half; primary teeth thirteen in number, small, rounded, rather regular as to size, shape and spacing; bear a few small secondary teeth on caudal edge; margin of valve between primary teeth is also notched with small teeth; ventral edge of tip is notched with small teeth, dorsal edge devoid of teeth at apex, fifteen present on ventral edge; area of ducts somewhat granular, though elongate ducts are present, circular duct openings visible; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area and irregularly in the basal region; the two valves of the pair are joined one to the other by an elongate, distinct, heavily chitinized connection present on the dorsal edge at about one-third the length.

Deltocephalus flavicosta Stal.

(Pl. XXIII, fig. 9; pl. XXX, fig. 9.)

Length, 1 mm.; greatest width, 0.1 mm. Apical portion bearing teeth occupies a little more than one-half the length, is slightly wider than the basal portion, narrows caudad to apex; no preapical prominence; slightly curved, tip narrowed, extreme apex bluntly rounded, chitinization moderately heavy; strengthening rod extends caudad as far as last primary tooth. Toothed area on dorsal edge occupies a little more than the apical half; teeth twelve to thirteen in number, small, rounded, rather regular in size, shape and spacing; bear a few small secondary teeth along the caudal edge; margin of valve between primary teeth is also notched with small secondary teeth; tip notched with small teeth on ventral edge, dorsal edge devoid of teeth at apex, eleven present on ventral edge; area of ducts somewhat granular in appearance, though elongate ducts are visible; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and irregularly in the basal area; the two valves of the pair are joined one to the other by an elongate, curved, heavily chitinized connection present on the dorsal edge at about one-fourth the length.

Deltocephalus debilis Uhler.

(Pl. XXX, fig. 10.)

Length, 1.33 mm.; greatest width, 0.15 mm. About the same width for entire length beyond curved basal connection, narrows caudad to apex; preapical prominence wanting; distinctly curved, tip gradually narrowed, extreme apex rounded, chitinization moderately heavy; strengthening rod extends caudad as far as fourth dorsal tooth from apex. Toothed area on dorsal edge occupies apical two-fifths of length; primary teeth thirteen to fourteen in number, small, usually rounded, irregular as to size, shape and spacing; for the most part bear no secondary teeth, though a few irregular secondary teeth are present; the margin of the valve between the primary teeth is notched with small, irregular teeth; the tip is slightly and irregularly roughened, but bears no distinct teeth; area of ducts conspicuous, granular in appearance, though elongate ducts are visible; open along ventral apical edge (five), at extreme apex (one), along dorsal edge of toothed area, and in the basal portion of the valve; the two valves of the pair are joined one to the other by a distinct, elongate, slightly curved, heavily chitinized connection present on the dorsal edge of the basal area, occupying more than one-third the entire length.

Deltocephalus parvulus Gillette.

(Pl. XXX, fig. 11.)

Length, 0.87 mm.; greatest width, 0.08 mm. About the same width for entire length beyond curved basal connection, tapers gradually caudad to apex; preapical prominence wanting; only slightly curved, tip narrowed, ends in sharp point, chitinization light; strengthening rod extends caudad almost to last dorsal primary tooth. Toothed area on dorsal edge occupies a little less than the apical half; primary teeth nine to ten in number, very small, rounded, fairly regular in size, shape and spacing, in most cases bear a few secondary teeth; margin of valve between primary teeth also bears small, regular secondary teeth, which point forward; tip devoid of teeth; ducts inconspicuous, their apices and circular openings alone being visible; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and in the basal area where elongate ducts are visible; the two valves of the pair are joined one to the other by an elongate, curved, distinct, heavily chitinized connection present on the dorsal edge of the basal area and occupying about one-fifth of the entire length.

Deltocephalus collinus Boheman.

(Pl. XXX, fig. 12.)

Length, 1.3 mm.; greatest width, 0.13 mm. Narrow and rodlike at base; beyond base a broader and more heavily chitinized portion extends to midpoint; apical portion is still wider, less heavily chitinized, tapers caudad apically; preapical prominence wanting; slightly curved, tip greatly narrowed, extreme apex narrowly rounded, rather blunt, chitinization moderately light; strengthening rod extends caudad as far as seventh primary tooth from apex. Toothed area on dorsal edge occupies a little less than the apical half; about seventeen primary teeth present, these are small, somewhat rounded, very irreg-

ular as to size, shape and spacing and may or may not bear a few small secondary teeth on the caudal edge; margin of valve between primary teeth notched with small, irregular teeth, especially caudad of apex; tip devoid of teeth; area of ducts conspicuous, granular in appearance, though elongate ducts are visible, circular duct openings visible; open along ventral apical edge (five), at extreme apex (one), along dorsal edge of toothed area, and irregularly in the basal area; the two valves of the pair are joined one to the other by a distinct, elongate, slightly curved, heavily chitinized connection present on the dorsal edge, occupying about one-fifth of entire length.

Aconura argentiolus (Uhler).

(Pl. XXXI, fig. 9)

Length, 1.77 mm.; greatest width, 0.11 mm. About the same width for entire length, tapers caudad to apex; bears no preapical prominence; slightly curved, tip narrowed, rather blunt, obtuse-angled point, chitinization very light; strengthening rod extends caudad to a point between last and next to last dorsal tooth. Toothed area on the dorsal edge occupies a little more than the apical half; teeth twenty-two in number, very small, in the general shape of a greatly flattened obtuse triangle with the caudal edge longer than the cephalic, rather irregular in size, shape and spacing; bear many small, regular secondary teeth along both edges, more numerous on the caudal edge, continuous along entire dorsal margin of valve toward apex; tip notched with small regular teeth on both dorsal and ventral edges, not continuous around the tip, teeth on ventral edge slightly larger than those or dorsal; areas of ducts inconspicuous; ducts invisible except for apices and circular openings; open along ventral apical edge, in extreme apex, along dorsal edge of toothed area, and irregularly in the basal portion of the valve.

Nephotettix curtipennis (Gillette and Baker).

(Pl. XXXI, fig. 10.)

Length, 2.5 mm.; greatest width, 0.25 mm. Apical toothed half slightly wider than basal portion, tapers caudad to apex; bears an indistinct, broadly rounded preapical prominence on ventral edge; only slightly curved, tip narrowed, ends in obtuse-angled point, chitinization moderately heavy; strengthening rod extends caudad beyond last distinct primary tooth. Toothed area on dorsal edge occupies the apical half; teeth twenty-four to twenty-five in number, of medium size, in the general shape of a very flat, obtuse triangle with the caudal side longer than the cephalic, fairly regular in size, shape and spacing; bear small, regular, secondary teeth on both edges, continuous around the apex of each tooth, seven to fifteen on caudal edge and one to four on cephalic edge; tip notched with small teeth on both dorsal and ventral edges, not continuous around the tip, about 55 on ventral edge, area of ducts conspicuous, granular in appearance though elongate ducts are visible, open along ventral apical edge (five), at extreme apex (one), along dorsal edge of toothed area, and a few in the basal region; the two valves of the pair are joined one to the other by an elongate, narrow, heavily chitinized connection extending the entire length on the basal area.

Driotura gammaroides (Van Duzee).

(Pl. XXIII, fig. 10; pl. XXXI, fig. 11.)

Length, 1.8 mm.; greatest width, 0.21 mm. Apical half slightly wider than basal half, tapers caudad to apex; bears only a suggestion of a preapical prominence on the ventral edge; slightly curved, tip narrowed with extreme apex narrowly rounded, chitinization moderately heavy; strengthening rod extends caudad beyond last distinct dorsal tooth. Toothed area on dorsal edge occupies the apical half; teeth twenty in number, of medium size, in the general shape of a flat, obtuse triangle with the caudal edge longer than the cephalic, rather regular in size, shape and spacing; bear small, regular secondary teeth on both edges, continuous around the apex of each tooth, seven to eighteen on caudal edge, two to seven on ventral edge; tip notched with small teeth on both dorsal and ventral edges, practically continuous around the tip though greatly reduced at extreme apex; those on ventral edge are larger and more distinct, about fifty-four present on ventral edge; area of ducts conspicuous, granular in appearance, duct openings visible; open along ventral apical edge (five), at extreme apex (one), along dorsal edge of toothed area, and irregularly in the basal area, the two valves of the pair are joined one to the other by an elongate, narrow, heavily chitinized connection present on the dorsal edge of the basal area for its entire length.

This ovipositor is very similar in general appearance to that of *Nephotettix curtipennis*.

Genus EUSCELIS Brulle.

The ovipositors of six species of this genus have been examined and a wide variety of forms found within the genus. *Euscelis exitiosus* (Uhler) and *Euscelis striolus* (Fallen), both in subgenus *Athysanus*, are not similar in any except their grosser details. *Euscelis anthracinus* (Van Duzee), in subgenus *Euscelis*, and *Euscelis comma* (Van Duzee), in subgenus *Conomellus*, are similar one to the other but not to any other species of the genus examined. *Euscelis curtesii* (Fitch) and *Euscelis bicolor* (Van Duzee), both in subgenus *Stirellus*, are very similar one to the other but not to any other species of the genus examined.

The ovipositors of the subgenus *Stirellus* are somewhat narrower in the basal half than in the apical half, which tapers to the apex and bears teeth along its dorsal edge. The teeth differ in number and in the number of secondary teeth they bear. The apex is notched with small teeth present on the ventral edge only. The area of ducts is conspicuous, granular in appearance, with the duct openings visible. The two valves of the pair are joined one to the other by an elongate, chitinized connection present on the dorsal edge of the basal area.

Euscelis exitiosus (Uhler).

(Pl. XXIII, fig. 11; pl. XXXI, fig. 1.)

Length, 2 mm.; greatest width, 0.2 mm. Apical portion, which occupies two-thirds of length, is slightly wider than basal portion, tapers caudad to apex; bears a distinct, angled, preapical prominence on ventral edge; only slightly curved beyond curved basal attachment, rather abruptly narrowed at tip, ends in sharp point, chitinization moderately heavy; strengthening rod extends caudad as far as last dorsal tooth. Toothed area on dorsal edge occupies apical two-thirds of length; teeth thirty-four to thirty-five in number, rather small, of a general triangular shape, with the caudal edge longer than the cephalic and the apex rounded, fairly regular in size, shape and spacing; bear small secondary teeth on both edges, not continuous around the apex of each tooth, eight to eighteen on caudal edge, two to four on cephalic edge; tip notched with small, regular teeth on both dorsal and ventral edges, practically continuous around the tip, about eighty on ventral edge between preapical prominence and extreme apex; area of ducts conspicuous, granular in appearance; open along ventral apical edge, along the dorsal edge of the toothed area, one in each tooth, and a very few in the basal area; the two valves of the pair are joined one to the other by a poorly defined connection which is slightly more heavily chitinized than the rest of the basal area, upon whose dorsal edge it is located.

Euscelis striolus (Fallen).

(Pl. XXIII, fig. 12; Pl. XXXI, fig. 2.)

Length, 1.1 mm.; greatest width, 0.16 mm. Apical portion occupying two-thirds of length but little wider than basal portion, narrows caudad to tip; bears no preapical prominence; only slightly curved, tip abruptly narrowed, ends in obtuse-angled point, chitinization moderately heavy; strengthening rod extends caudad as far as second dorsal tooth from apex. Toothed area on dorsal edge occupies apical two-thirds; teeth eleven to twelve in number, rather large, of a general triangular shape with the apices broadly rounded, fairly regular in size and shape, irregular in spacing; bear secondary teeth of various sizes and shapes on both edges, three to nine on caudal edge and one to four on cephalic edge; general arrangement of secondary teeth is very irregular; tip bears a few irregular teeth on the dorsal edge only, there is a slight irregularity of the margin on the ventral apical edge; area of ducts conspicuous, granular in appearance, circular duct openings easily visible; open along ventral apical edge, in extreme apex, along dorsal edge of toothed area, and in basal region where many elongate ducts are visible; the two valves of the pair are joined one to the other by an elongate, distinct, chitinized connection present on the dorsal edge of the basal area.

Euscelis anthracinus (Van Duzee).

(Pl. XXXI, fig. 3.)

Length, 1.4 mm.; greatest width, 0.18 mm. About the same width for entire length beyond curved basal connection; preapical prominence wanting; slightly curved, tip narrowed by broadly rounded ventral edge, extreme apex bluntly rounded, chitinization rather heavy; strengthening rod extends caudad as far as last dorsal tooth. Toothed area on dorsal edge occupies apical half;

teeth nine to ten in number, very small, rounded, fairly regular as to size, shape and spacing, being farther apart basally; bear a few small secondary teeth on caudal edge, margin of valve between teeth also notched with small, numerous secondary teeth; tip notched with small teeth on both dorsal and ventral edges, not continuous around the tip, about fifteen present on the ventral edge; area of ducts conspicuous, granular in appearance, though elongate ducts are visible; duct openings visible; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and in basal region, where many elongate ducts are visible; the two valves of the pair are joined one to the other by a distinct, elongate, curved, heavily chitinized connection present on the dorsal edge of the basal area; this connection bears a rounded prominence toward the caudal end.

Euscelis comma (Van Duzee).

(Pl XXIII, fig. 13, pl. XXXI, fig. 4)

Length, 1.5 mm.; greatest width, 0.22 mm. About the same width for entire length beyond curved basal connection, tapers caudad to apex; no preapical prominence; only slightly curved, tip narrowed by broadly curving ventral edge, extreme apex narrowly rounded, chitinization rather heavy; strengthening rod extends caudad to within a short distance of apex. Toothed area on dorsal edge occupies a little less than the apical half; teeth numerous, small, rounded, very irregular as to size, shape and spacing and present an irregularly crenulate margin; tip bears no distinct teeth but is irregularly roughened; area of ducts conspicuous, granular in appearance, with many elongate ducts visible; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and in the basal region where many elongate ducts are visible; the two valves of the pair are joined one to the other by an elongate, distinct, heavily chitinized connection present on the dorsal edge of the basal area; it is a little less than half the entire length and at the point of greatest width is about one-half the width of the valve; bears an indistinct, broadly rounded prominence a little caudad of the midpoint.

Euscelis curtisii (Fitch).

(Pl. XXXI, fig 5.)

Length, 1.1 mm.; greatest width, 0.12 mm. Apical half slightly wider than basal half, bears no preapical prominence; only slightly curved beyond curved basal attachment, gradually narrowed, ends in narrowly rounded extreme apex, chitinization moderately light; strengthening rod extends caudad as far as next to last dorsal tooth. Toothed area on dorsal edge occupies the apical half; teeth fourteen to sixteen in number, small, rounded, fairly regular in size, shape and spacing, though not entirely so; bear a few secondary teeth on the caudal edge and an occasional secondary tooth on the cephalic edge; tip notched with small teeth on ventral edge only, dorsal edge devoid of teeth at extreme apex, ten present on ventral edge; area of ducts conspicuous, granular in appearance, openings visible; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and in basal region where elongate ducts are visible; the two valves of the pair are joined one to the other by a distinct, elongate, slightly curved, chitinized connection present on the dorsal edge of the basal area.

Euscelis bicolor (Van Duzee).

(Pl. XXXI, fig. 6; pl. XXIII, fig. 14.)

Length, 0.92 mm.; greatest width, 0.11 mm. Apical portion slightly wider than basal portion, tapers caudad to apex; no preapical prominence; distinctly curved, tip gradually narrowed, ends in narrowly rounded extreme apex, chitinization rather light; strengthening rod extends caudad as far as next to last dorsal tooth. Toothed area on dorsal edge occupies apical two-fifths of length; teeth twelve to thirteen in number, small, rounded, fairly regular in size, shape and spacing; bear a few small secondary teeth on caudal edge, margin of valve also notched with small secondary teeth; tip notched with small teeth on ventral edge only, eight to ten in number; area of ducts conspicuous, granular in appearance, duct openings visible; open along ventral apical edge, at extreme apex, along dorsal edge of toothed area, and in basal region, where elongate ducts are visible; the two valves of the pair are joined one to the other by an elongate connection only slightly more heavily chitinized than the rest of the basal area, occupying about one-sixth of the entire length.

Genus EUTETTIX Van Duzee.

The ovipositors of two species of this genus have been examined and found to be generally similar, though possessing many differences. In each case the basal half is somewhat narrower than the apical half, which narrows toward the apex and bears teeth along its dorsal edge. The teeth vary in number, size, shape, and possession of secondary teeth in the two species. The tip is notched with small teeth on one or both edges. The area of ducts is conspicuous, granular in appearance, with the duct openings visible. The two valves of the pair are joined one to the other by a chitinous connection present on the dorsal edge of the basal area.

Eutettix cinctus Osborn and Ball.

(Pl. XXIV, fig. 1; pl. XXXI, fig 8.)

Length, 1.5 mm.; greatest width, 0.17 mm. Apical portion but slightly wider than basal portion, narrowed caudad toward apex; no preapical prominence; distinctly curved, tip narrowed, extreme apex broadly rounded, chitinization moderately heavy; strengthening rod extends caudad as far as fourth dorsal tooth from apex. Toothed area on dorsal edge occupies apical half of valve; teeth fourteen in number, of medium size, rounded, fairly regular in size, shape and spacing; bear secondary teeth, one to four on caudal edge; cephalic edge may also bear a single secondary tooth; margin of valve is notched with small secondary teeth between primary teeth; a few faintly visible teeth are present on the ventral edge of the tip, the dorsal edge is devoid of teeth at the extreme apex, about nine present on the ventral edge; area of ducts conspicuous, granular in appearance, duct openings easily visible; open along ventral apical edge (seventeen to nineteen), at extreme apex (three), along dorsal edge of toothed area, and in the basal region where elongate ducts are visible; the

two valves of the pair are joined one to the other by a distinct, elongate, curved, heavily chitinized connection present on the dorsal edge of the basal area; bears a distinct, rounded prominence about midway.

Eutettix strobi (Fitch).

(Pl. XXIV, fig. 2; pl. XXXI, fig. 7.)

Length, 1.3 mm.; greatest width, 0.17 mm. Apical portion somewhat wider than basal portion, narrows caudad to apex; preapical prominence wanting; slightly curved, tip narrowed by curving dorsal edge, ends in broadly rounded extreme apex, chitinization medium; strengthening rod extends caudad as far as fifth dorsal tooth from apex. Toothed area on dorsal edge occupies a little more than the apical half; teeth twenty-one to twenty-four in number, large, somewhat irregularly rounded with the caudal edge longer and more gently sloping than the cephalic edge; bear small secondary teeth on both edges, three to seven on caudal edge and one to three on cephalic edge; tip is notched with small teeth on both dorsal and ventral edges, not continuous around the tip, fifteen to nineteen on ventral edge; area of ducts conspicuous, granular in appearance, duct openings easily visible; open along ventral apical edge (fourteen), at extreme apex (one), along dorsal edge of toothed area, and in basal region where elongate ducts are visible; the two valves of the pair are joined one to the other by a rather short, distinct, heavily chitinized connection present on the dorsal edge in the basal region.

Genus PHLEPSIUS Fieber.

The ovipositors of three species of this genus have been examined and found to be generally similar. The ovipositor in each case is about the same width for entire length and tapers caudad to the apex. The toothed area on the dorsal edge occupies from a third to a half the apical length. The primary teeth vary in number, size, shape and number of secondary teeth in the various species. The tip is notched with small teeth on both edges in every case. The area of ducts is conspicuous, granular in appearance, with some elongate ducts visible and with duct openings visible; the two valves of the pair are joined one to the other by an elongate, chitinized connection present on the dorsal edge of the basal area.

Phlepsius spatulatus Van Duzee.

(Pl. XXIV, fig. 8; pl XXXII, fig 10.)

Length, 1.9 mm.; greatest width, 0.25 mm. About the same width for entire length, tapers caudad to apex; bears a suggestion of a preapical prominence on the ventral edge; slightly curved, narrowed by curving ventral edge, rather bluntly rounded at extreme apex, chitinization heavy; strengthening rod extends cauded as far as fifth dorsal tooth. Toothed area on dorsal edge occupies apical two-fifths; teeth fifteen to eighteen in number, of medium size, rounded, rather irregular as to size, shape and spacing; bear a few irregular secondary teeth on the caudal edge; cephalic edge of some teeth

also bears a single secondary tooth; margin of valve between primary teeth notched with small secondary teeth; tip notched with small, irregular teeth on both edges; area of ducts conspicuous, granular in dorsal region, duct-like in ventral region, circular duct openings visible; open at ventral apical edge (seven), at extreme apex (one), along dorsal edge of toothed area, and in basal region; the two valves of the pair are joined one to the other by a distinct, elongate, heavily chitinized connection present on the dorsal edge of the basal area and occupying about one-third the length.

Phlepsius excultus (Uhler).

(Pl. XXIV, fig. 4; pl. XXXII, fig. 9.)

Length, 1.8 mm.; greatest width, 0.17 mm. About the same width for entire length, tapers caudad to apex; bears a suggestion of a preapical prominence in the ventral edge, extreme apex rounded, chitinization moderately heavy; strengthening rod extends caudad as far as fourth dorsal tooth from apex. Toothed area on dorsal edge occupies a little more than the apical third of the length; teeth fifteen to seventeen in number, rather small, rounded, fairly regular in size and shape but uneven in spacing; bear a few secondary teeth on caudal edge, and a few primary teeth bear a single secondary tooth on the cephalic edge, margin of valve between primary teeth bears small secondary teeth; tip notched with small teeth on both dorsal and ventral edges, practically continuous around the tip; eight large teeth on ventral edge; these may be simple or may bear secondary teeth, irregular as to arrangement; area of ducts conspicuous, ducts elongate for the most part though a granular area is present dorsally, duct openings visible; open along ventral apical edge (six), at extreme apex (one), along dorsal edge of toothed area, and in the basal region; the two valves of the pair are joined one to the other by a distinct, elongate heavily chitinized connection present on the dorsal edge of the basal area, occupying more than a third of the total length, this connection irregularly roughened along its dorsal edge.

Phlepsius irroratus (Say).

(Pl. XXIV, fig. 5, pl. XXXII, fig. 8.)

Length, 1.5 mm.; greatest width, 0.17 mm. About the same width for entire length beyond curved basal attachment, narrows caudad to apex; preapical prominence wanting; slightly curved, tip gradually narrowed, narrowly rounded at extreme apex, chitinization moderately light; strengthening rod extends caudad as far as second dorsal tooth from apex. Toothed area on dorsal edge occupies a little less than the apical half; teeth nineteen to twenty in number, of medium size, in the general shape of an obtuse triangle with caudal edge longer than the cephalic and the apex rounded broadly, fairly regular as to size shape and spacing, but not entirely so; bear a few secondary teeth on caudal edge and also a few bear a single secondary tooth on the cephalic edge; tip is notched with small, indistinct teeth on both dorsal and ventral edge, not continuous around the tip, about fifteen on ventral edge; area of ducts conspicuous, granular in appearance, duct openings easily visible; open along ventral apical edge (ten), at extreme apex (one), along dorsal edge of toothed area, and in the basal region where elongate ducts are

visible; the two valves of the pair are joined one to the other by a heavily chitinized connection present on the dorsal edge of the basal area, occupying about a fourth of the entire length and a half of the width.

Genus ACINOPTERUS Van Duzee.

The ovipositors of three species of this genus have been examined and found to be very similar. In each case the ovipositor is greatly curved, the basal portion only slightly narrower than the apical portion, which bears teeth along its dorsal edge. The primary teeth are few in number, and differ in number and in the number of secondary teeth they bear in the various species. The margin of the valve between the primary teeth is notched with small teeth. The tip in each case is notched with small teeth on both dorsal and ventral edges. The area of ducts may or may not be conspicuous, when visible granular in appearance with duct openings visible. The two valves of the pair are joined one to the other by an elongate, curved, chitinous connection present on the dorsal edge of the basal area.

Acinopterus acuminatus Van Duzee.

(Pl XXIV, fig 6, pl XXXII, fig 3)

Length, 1.5 mm.; greatest width, 0.12 mm. Apical portion only slightly wider than basal portion, tapers slightly caudad; bears a small preapical prominence on the ventral edge; greatly curved, chitinization moderately light; strengthening rod extends caudad as far as last or next to last dorsal tooth of large size Toothed area on dorsal edge occupies somewhat less than the apical half; primary teeth seven in number, small, rounded, regular as to size and shape, unevenly spaced; bears three to four small secondary teeth on the caudal edge, margin of valve between primary teeth bears numerous small, regular, secondary teeth; tip notched with small teeth on both dorsal and ventral edges, not continuous around the tip, about fifteen present on the ventral edge; area of ducts conspicuous, granular in appearance, circular duct openings visible; open along ventral apical edge (seven), at extreme apex (two), along dorsal edge of toothed area, and in the basal region; the two valves of the pair are joined one to the other by a distinct, curved, heavily chitinized connection present on the dorsal edge of the basal area.

Acinopterus viridis Ball.

(Pl. XXXII, fig 1)

Length, 1.7 mm.; greatest width, 0.16 mm. Apical portion only slightly wider than basal portion, narrowed caudad at apex, bears no preapical prominence; greatly curved, tip narrowed, ends in rounded extreme apex, chitinization light; strengthening rod extends caudad almost to apex. Toothed area on dorsal edge occupies the apical third; only two primary teeth present, these located near the base of the toothed area, small, rounded, bear two to three small secondary teeth on their caudal edges; the margin of the valve is notched with many small, regular secondary teeth; tip is notched on both

edges with small teeth, continuous around the tip, about ten on ventral edge; area of ducts inconspicuous, ducts invisible except for circular openings; open along ventral apical edge (six), at extreme apex (one), along dorsal edge of toothed area, and in basal area; the two valves of the pair are joined one to the other by a poorly defined, elongate connection present on the dorsal edge of the basal area, only slightly more heavily chitinized than the rest of the basal area.

Acinopterus angulatus Lawson.

(Pl. XXXII, fig. 2.)

Length, 1.2 mm.; greatest width, 0.12 mm. Apical portion only slightly wider than basal portion, narrows slightly caudad at apex; no distinct preapical prominence present; greatly curved, tip narrowed, extreme apex rounded, chitinization moderately heavy, heavier than in *A. acuminatus* and *A. viridis*; strengthening rod extends caudad as far as next to last primary tooth. Toothed area on dorsal edge occupies a little more than the apical third; teeth eight in number, small, rounded, regular in size and shape, somewhat unevenly spaced; bear secondary teeth on caudal edge, three to four in number; the margin of valve between primary teeth is notched with small, numerous, regular, secondary teeth; tip notched with small teeth on both dorsal and ventral edges, practically continuous around the tip, about fifteen on ventral edge; area of ducts conspicuous, granular in appearance, circular duct openings visible; open along ventral apical edge (five to six), at extreme apex (one), along dorsal edge of toothed area, and in basal region; the two valves of the pair are joined one to the other by a distinct, elongate, heavily chitinized connection present on the dorsal edge of the basal area.

Genus THAMNOTETTIX Zetterstedt.

The ovipositors of two species of this genus have been examined and found to be generally similar. In each case the basal half is distinctly narrower than the apical half, which narrows caudad at the apex and bears teeth along its dorsal edge. The primary teeth differ in number, shape, and number of secondary teeth they bear in the two species. The tip is notched with small teeth on both edges. The area of ducts is conspicuous, granular in appearance, with the duct openings visible. The two valves of the pair are joined one to the other by a heavily chitinized connection present on the dorsal edge of the basal area.

Thamnotettix clitellarius (Say).

(Pl. XXXII, fig. 5.)

Length, 1.4 mm.; greatest width, 0.18 mm. Apical portion plainly wider than basal portion, narrows caudad toward apex; bears a very small preapical prominence on ventral edge; slightly curved, tip narrowed, extreme apex broadly rounded, chitinization medium; strengthening rod extends caudad as far as fourth dorsal tooth from apex. Toothed area on dorsal edge occupies a little more than the apical half; teeth twenty to twenty-three in number, of

medium size, of a general triangular shape, with the caudal edge longer than the cephalic and the apex rounded broadly, fairly regular as to size, shape, and spacing, though not entirely so; bear small secondary teeth on caudal edge and a few also bear a single secondary tooth on the cephalic edge; tip notched with small teeth on both edges, not continuous around the tip, those on ventral edge larger and more distinct, about fourteen present on ventral edge; area of ducts conspicuous, granular in appearance, circular duct openings visible; present along ventral apical edge (twelve), at extreme apex (one), along dorsal edge of toothed area, and in basal region where elongate ducts are visible; the two valves of the pair are joined one to the other by a distinct, heavily chitinized, rather short, rectangular connection present on the dorsal edge of the basal area.

Thamnotettix longulus Gillette and Baker.

(Pl. XXXII, fig 4)

Length, 1.3 mm.; greatest width, 0.17 mm. Apical portion distinctly wider than basal portion, tapers caudad at apex; no preapical prominence; slightly curved, tip narrowed, extreme apex narrowly rounded, chitinization medium; strengthening rod extends caudad as far as sixth dorsal tooth from apex. Toothed area on dorsal edge occupies somewhat more than apical half; thirty-one primary teeth present, in the general shape of an obtuse triangle, of medium size, fairly regular as to size and shape but not entirely so, uneven in spacing; bear small secondary teeth on both edges, four to twelve on caudal edge and one to four on cephalic edge, secondary teeth continuous around the apex of each tooth; tip notched with small teeth on both dorsal and ventral edge, not continuous around the apex, eight on ventral edge; area of ducts conspicuous, granular in appearance, duct openings visible; open along ventral apical edge (eight), at extreme apex (one), along dorsal edge of toothed area (about one to each tooth), and in the basal area; the two valves of the pair are joined one to the other by a distinct, elongate, heavily chitinized connection present on the dorsal edge of the basal area, occupies less than a fifth of the entire length.

Genus CHLOROTETTIX Van Duzee.

The ovipositors of two species of this genus have been examined and found to be generally similar. The basal third may or may not be narrower than the apical two-thirds, which tapers to the apex and bears teeth along its dorsal edge. The primary teeth differ in number, shape, and number of secondary teeth in the two species. The tip is notched on both edges with small teeth, not continuous around the tip. The area of ducts is granular in appearance and the duct openings are visible. The two valves of the pair are joined one to the other by a chitinous connection present on the dorsal edge of the basal area.

Chlorotettix spatulatus Osborn and Ball.

(Pl. XXIV, fig. 7; pl. XXXII, fig. 6.)

Length, 1.5 mm.; greatest width, 0.24 mm. Apical portion much wider than basal portion, tapers caudad at apex; preapical prominence wanting; slightly curved, tip rather abruptly narrowed, extreme apex narrowly rounded, chitinization medium; strengthening rod extends caudad as far as last primary tooth. Toothed area on dorsal edge occupies the apical two-thirds; teeth twenty-seven to twenty-eight in number, of medium size, rather irregular as to shape, some rounded, some triangular and some flat across the top; bear two to seven secondary teeth on the caudal edge and may or may not bear one to three secondary teeth on the cephalic edge; tip notched with small teeth on both edges, not continuous around the tip, nine to ten on ventral edge; area of ducts conspicuous, granular in appearance though many elongate ducts are visible, duct openings visible; open along ventral apical edge (eight), at extreme apex (one), along dorsal edge of toothed area, and in basal area; the two valves of the pair are joined one to the other by an elongate, rectangular, chitinized connection present on the dorsal edge of the basal area, only slightly more heavily chitinized than the rest of the valve, occupying about one-sixth of entire length.

Chlorotettix galbanatus Van Duzee.

(Pl. XXIV, fig 8; Pl. XXXII, fig 7.)

Length, 1.4 mm.; greatest width, 0.21 mm. About the same width for entire length, apical portion very slightly narrower than basal portion, tapers caudad to apex; no preapical prominence; slightly curved, tip gradually narrowed, extreme apex bluntly rounded, chitinization medium; strengthening rod extends caudad as far as third dorsal tooth from tip. Toothed area on dorsal edge occupies somewhat less than the apical two-thirds; teeth twenty-eight in number, of medium size, some rounded, others of a general triangular shape, evenly spaced; bear secondary teeth, two to eight on caudal edge and an occasional single secondary tooth on the cephalic edge; tip notched with small teeth on both edges, not continuous around the tip, ten present on ventral edge; area of ducts conspicuous, granular in appearance, circular duct openings visible; open along ventral apical edge (thirteen), at extreme apex (one), along dorsal edge of toothed area, and in the basal region, where elongate ducts are visible; the two valves of the pair are joined one to the other by a distinct, curved, heavily chitinized connection present on the dorsal edge of the basal area, occupying a little less than a fourth of the entire length.

Jassus olitorius Say.

(Pl XXXIII, fig. 2.)

Length, 3.7 mm.; greatest width, 0.2 mm. Very long, narrow and rodlike, apical portion which bears teeth only slightly if any wider than basal rod tapers only at apex; no distinct preapical prominence present; distinctly curved, tip narrowed, rounded at extreme apex, chitinization moderately heavy; strengthening rod extends caudad as far as sixth dorsal tooth. Toothed area on dorsal edge occupies about the apical fourth; eleven teeth present on each valve with a large median tooth present between teeth one and two;

apical teeth very small and broadly rounded, distal teeth larger and more sharply pointed; bear no secondary teeth; tip bears no teeth; area of ducts conspicuous, ducts elongate, rather straight, circular openings visible; open along ventral apical edge (twenty-two), at extreme apex (one), along dorsal edge of toothed area, very noticeably in teeth three and four, in each of which three to four ducts open, and in the basal rod; the two valves of the pair are joined one to the other by a distinct, elongate, narrow, heavily chitinized connection present on the dorsal edge of the basal rod.

Tinobregmus vittatus Van Duzee.

(Pl. XXXIII, fig 1)

Length, 2.7 mm.; greatest width, 0.19 mm. Long, narrow and rodlike, apical toothed portion only slightly wider than basal rod, tapers caudad at apex; no preapical prominence; distinctly curved, tip evenly narrowed, extreme apex rounded, chitinization moderately heavy, heavier than in *Jassus olitorius;* strengthening rod extends caudad as far as eighth dorsal tooth. Toothed area on dorsal edge occupies apical third; teeth ten to eleven in number, apical teeth small and broadly rounded, distal teeth larger and more sharply pointed; bear no secondary teeth; tip bears no teeth; area of ducts conspicuous, ducts elongate, rather straight, duct openings visible; open along ventral apical edges (twelve), at extreme apex (one), along dorsal edge of toothed area, and in the entire length of basal rod; the two valves of the pair are joined one to the other by a distinct, elongate, narrow, heavily chitinized connection present on the dorsal edge of the basal rod, occupying about one-fifth of the length of the basal shaft.

This ovipositor is very similar to that of *Jassus olitorius*.

Cicadula punctifrons var. *repleta* Fieber.

(Pl. XXIV, fig. 9; pl. XXXIII, fig 3)

Length, 2.2 mm.; greatest width, 0.17 mm. About the same width for entire length, narrows caudad at apex; no preapical prominence; slightly curved, tip narrowed by curving ventral edge, bears a finely toothed prominence on the dorsal edge, extreme apex narrowly rounded, chitinization very light; strengthening rod extends caudad as far as fourth dorsal tooth from apex. Toothed area on dorsal edge occupies the apical two-fifths; teeth fifteen in number, rather large, rounded, regular as to size, shape and spacing; bear a few fine secondary teeth on both edges, continuous around the apices of the primary teeth, those on caudal edge larger and more distinct than those on ventral edge, two to eight present on the ventral edge; there are fine, radiating lines extending from the interior of each tooth to the margin; the tip is notched with small teeth on both edges, not continuous around the tip, twenty-five on ventral edge; area of ducts inconspicuous, ducts invisible except for circular openings, which are easily visible; open along ventral apical edge (five), at extreme apex (one), along dorsal edge of toothed area, and in the basal area; the two valves of the pair are joined one to the other by a poorly defined, elongate, lightly chitinized connection present on the dorsal edge of the basal area, occupies about one-fourth the entire length.

Genus BALCLUTHA Kirkaldy.

The ovipositors of two species of this genus have been examined and found to be similar. The basal portion is somewhat narrower than the apical portion. The point of greatest width is between three-fourths and four-fifths the length of the valve, beyond which the valve tapers to a very narrow apex, sharply pointed or narrowly rounded. The valve bears only very small teeth located at the apex. The area of ducts may or may not be conspicuous, is granular in appearance with the duct openings visible. The two valves of the pair are joined one to the other by an elongate, lightly chitinized connection present on the dorsal edge of the basal area.

Balclutha punctata (Thunberg).

(Pl. XXIV, fig. 10; pl XXXIII, fig. 4)

Length, 0.88 mm.; greatest width, 0.1 mm. Apical portion somewhat wider than basal portion, point of greatest width about three-fourths the length, tapers caudad from this point to the apex; distinctly curved, tip greatly narrowed, extreme apex narrowly rounded, chitinization very light; strengthening rod extends caudad to within a short distance of the apex. The valve is toothed only on its dorsal apical edge for about one-sixth the length, teeth numerous, very small, regular; area of ducts inconspicuous, faintly granular in appearance, duct openings visible; open along ventral apical edge, at extreme apex, along dorsal apical edge, and in the basal region; the two valves of the pair are joined one to the other by a lightly chitinized, elongate, narrow connection present on the dorsal edge of the basal area.

Balclutha impicta (Van Duzee).

(Pl. XXIV, fig. 11, pl. XXXIII, fig 5.)

Length, 0.88 mm.; greatest width, 0.09 mm. Apical portion slightly wider than basal portion, point of greatest width about four-fifths the length; only slightly curved, tip greatly narrowed, extreme apex very sharply pointed, chitinization light, though heavier than in *B. punctata;* strengthening rod extends caudad almost to apex. The dorsal edge is toothed only for the apical sixth of its length; teeth numerous, very small and regular; ventral edge also bears a few small teeth at the apex, farther apart than those on the dorsal edge, about ten in number; area of ducts conspicuous, granular in appearance, openings visible; open along ventral apical edge, at extreme apex, along dorsal apical edge, and in the basal area; the two valves of the pair are joined one to the other by a distinct, elongate, narrow connection present on the dorsal edge of the basal area.

Eugnathodus abdominalis (Van Duzee).

(Pl. XXIV, fig. 12; pl. XXXIII, fig. 6)

Length, 0.72 mm.; greatest width, 0.09 mm. Apical half slightly wider than basal half, point of greatest width is about three-fourths the length, beyond this point the valve tapers to the apex; distinctly curved, tip greatly but unevenly narrowed, extreme apex very sharply pointed, chitinization very

light; strengthening rod extends caudad almost to apex The toothed area on the dorsal edge occupies only the narrowed portion of the apex; these teeth are very small, regular, numerous; the ventral edge bears no teeth at the apex, but somewhat back from the apex on the widened portion the ventral edge is notched with many fine, indistinct teeth; area of ducts conspicuous, granular in appearance, duct openings visible; open along ventral apical edge, at extreme apex, along dorsal apical edge, and in basal region; there is no evidence of a chitinous connection between the two valves of the pair.

This ovipositor is similar in appearance to the ovipositors of the genus *Balclutha* examined.

TRIBE TYPHLOCYBINI (Kirschbaum).

Dikraneura abnormis (Walsh).

(Pl XXIV, fig 13, pl. XXXIII, fig 7)

Length, 0 7 mm.; greatest width, 0.08 mm. Basal half narrow and rodlike, apical half wider, flat, toothed, tapers caudad to apex; basal portion greatly curved, apical portion only slightly curved; tip greatly narrowed, extreme apex narrowly rounded, chitinization moderately light; strengthening rod extends caudad as far as sixth dorsal tooth from apex. Toothed area on dorsal edge occupies the apical half; the two valves of the pair are not identical as to teeth, the one having few and the other many; the one having more bears twenty-five primary teeth, these rather small, in the general shape of an obtuse triangle, fairly regular as to size and shape, much reduced in size apically, bear secondary teeth along the caudal edges, three to six in number; the tip is notched with small teeth on both edges, not continuous around the tip, four on the ventral edge; area of ducts inconspicuous, ducts visible, elongate, rather few in number, visible openings present only along dorsal edge of toothed area and in basal area; no distinct chitinous connection between the two valves present.

Genus EMPOASCA Walsh.

The ovipositors of five species of this genus have been examined and found to be very similar. In this genus the two valves of the pair are not identical, but differ in length, width, and size and number of teeth. The shorter, narrower valve bears many very small, regular teeth along its dorsal edge. The longer, broader valve bears comparatively few large teeth, which in turn bear small secondary teeth. Neither valve in any of the species examined bears teeth for more than the apical fifth of its length. Except in one species the tip of the valve is notched with small teeth. The area of ducts may or may not be conspicuous; ducts elongate, few in number.

Empoasca trifasciata Gillette.

(Pl XXXIII, fig. 10.)

Length, 0.8 mm.; greatest width, 0.08 mm. Narrow and rodlike, apical toothed portion only slightly wider than basal shaft; distinctly curved, tip narrowed, extreme apex narrowly rounded, chitinization moderately light; strengthening rod extends caudad as far as second dorsal tooth. Toothed area

on dorsal edge occupies the apical fifth of the valve; the two valves of the pair differ as to number and arrangement of teeth; the shorter, narrower valve bears many small, regular teeth along its dorsal edge; the longer, broader valve bears thirteen large primary teeth along its dorsal edge, these rounded, regular, and bear one to three secondary teeth along their caudal edges; the tip is notched with small teeth on both dorsal and ventral edges, not continuous around the tip, seven on ventral edge of valve bearing small teeth, eleven on ventral edge of valve bearing large teeth; area of ducts conspicuous, ducts easily visible, elongate, rather few in number; open at apex, along dorsal edge of toothed area, and in basal area; no distinct chitinous connection present.

Empoasca smaragdula (Fallen).

(Pl XXXIII, fig 11.)

Length, 2 mm.; greatest width, 0.11 mm. Narrow and rodlike, about the same width for entire length, tapers caudad at apex; distinctly curved, tip narrowed, extreme apex narrowly rounded, chitinization medium; strengthening rod extends caudad as far as third dorsal tooth. Toothed area on dorsal edge occupies about the apical seventh of the length; the two valves of the pair are not identical; the one is shorter, narrower, and bears only very small teeth along its dorsal edge; the longer, wider valve bears thirteen large primary teeth along its dorsal edge, flatly rounded, fairly regular as to size, shape and spacing; bear a few indistinct secondary teeth; the tip of the larger valve is notched with small, indistinct, irregular teeth on both dorsal and ventral edges, continuous around the apex; area of ducts conspicuous, ducts easily visible, elongate, few in number; open at apex and along basal shaft; the dorsal edge of the basal shaft is irregularly roughened; no distinct chitinous connection present.

Empoasca obtusa Walsh.

(Pl XXIV, fig 14; pl XXXIII, fig 12)

Length, 0.9 mm.; greatest width, 0.05 mm Consists of a narrow, rodlike basal shaft and a slightly wider, toothed apical portion which tapers caudad to apex; distinctly curved, tip only slightly narrowed, extreme apex broadly rounded, chitinization moderately light; strengthening rod extends caudad as far as second dorsal tooth. The two valves of the pair are not identical; the shorter, narrower valve bears only very small, regular teeth along its dorsal edge; the longer, wider valve is toothed along its apical seventh with seven primary teeth, these of medium size, rather flatly rounded, fairly regular as to size, shape and spacing, though smaller apically, and bear a few irregular, indistinct, secondary teeth; no distinct teeth present on tip; area of ducts rather conspicuous, ducts visible, few in number, elongate; open apically, along dorsal edge of toothed area, and along basal shaft.

Empoasca livingstoni Gillette.

(Pl. XXXIII, fig. 14.)

Length, 2 mm.; greatest width, 0.11 mm. Narrow and rodlike, about the same width for entire length, tapers caudad at apex; distinctly curved, tip greatly narrowed, extreme apex ends in acute-angled point, chitinization very light; strengthening rod extends caudad as far as fifth dorsal tooth. The two valves of the pair are not identical; the shorter, narrower valve bears only

very small, regular teeth for a short distance on its dorsal edge; the longer, wider valve bears thirteen primary teeth along the apical sixth of its dorsal edge, medium in size, somewhat triangular in shape, with the caudal edge longer than the cephalic, fairly regular in size, shape and spacing; bear small secondary teeth along caudal edge, three to seven in number; tip of longer valve notched with small teeth, continuous around the tip, thirteen on ventral edge; area of ducts inconspicuous, ducts invisible except for circular openings; open at apex, along dorsal edge of toothed area, and in basal shaft.

Empoasca mali (LeBaron).

(Pl XXXIII, fig. 13)

Length, 0.8 mm.; greatest width, 0.03 mm Very narrow and rodlike, apical toothed portion only very little wider than basal shaft; greatly curved, tip slightly narrowed, extreme apex narrowly rounded, chitinization light; strengthening rod extends caudad as far as third dorsal tooth. The two valves of the pair are not identical; the shorter, narrower valve bears only very small, regular teeth along its dorsal edge for a short distance; the longer, wider valve bears eighteen primary teeth along the apical sixth of its dorsal edge, these of medium size, regular as to size, shape and spacing, smaller apically, and bear a few very fine and indistinct secondary teeth on the caudal edge; the tip of the longer valve is notched with small teeth on both edges, not continuous around the tip, about seven on the ventral edge; area of ducts inconspicuous, ducts invisible except for circular openings; open at apex and a few in the basal shaft.

Genus ERYTHRONEURA Fitch.

The ovipositors of two species of this genus have been examined and found to be similar one to the other and also to the ovipositors of the genus *Empoasca*. In this genus the two valves of the pair are not identical, but differ as to length, width, and size and number of teeth. In one species the small, more numerous teeth are borne by the longer, wider valve; in the other species the condition is reversed. The teeth do not occur except on the apical fourth of the valve. The area of ducts is inconspicuous, ducts when visible elongate, duct openings visible.

Erythroneura tricincta Fitch.

(Pl. XXXIII, fig. 8.)

Length, 1.2 mm; greatest width, 0.09 mm. Narrow and rodlike, the apical toothed portion only slightly wider than the basal shaft, tapers caudad at apex; distinctly curved, tip narrowed, extreme apex rounded, chitinization very light; strengthening rod extends caudad to a point about two-fifths the length of the toothed portion of the longer valve. The two valves of the pair are not identical; the longer, wider valve bears a great many very small, regular teeth along its dorsal edge for the apical fourth; the shorter, narrower valve bears slightly larger, less numerous, regular teeth along its dorsal apical edge; tip notched with teeth on both edges, not continuous around the tip,

about twelve on the ventral edge of the longer valve; area of ducts inconspicuous, ducts invisible except for openings; open in apex and along basal shaft.

Erythroneura vulnerata Fitch.

(Pl XXXIII, fig. 9)

Length, 0.8 mm.; greatest width, 0.06 mm. Narrow and rodlike, apical toothed portion only slightly wider than basal shaft, tapers caudad to apex; distinctly curved, tip narrowed, extreme apex rounded, chitinization moderately light; strengthening rod extends caudad as far as third dorsal tooth. The two valves of the pair are not identical; the shorter, narrower valve bears very small teeth for a short distance along its dorsal apical edge; the longer, wider valve bears ten primary teeth along its dorsal edge, occupying the apical sixth, these of medium size, in the general shape of an obtuse triangle, fairly regular in size, shape and spacing, bear two to five small secondary teeth on caudal edge; tip notched with small teeth on both edges, continuous around apex, about ten present on ventral edge of longer valve; area of ducts inconspicuous, ducts elongate; open apically and along the basal shaft.

CONCLUSIONS.

An examination of the descriptions and plates leads to several conclusions. The various subfamilies are not distinctly set apart by the characters of the ovipositor. While it is true that in general the ovipositors of the Bythoscopinæ have regular, rounded teeth; those of the Cicadellinæ are toothed for nearly their entire length and have elongate, curved ducts; those of the Gyponinæ are stout and heavily chitinized; and those of the Jassinæ have a granular duct area and a chitinous connection between the two valves of the pair; yet these characters are not found in all the members of the subfamily and are not exclusively found in the subfamily. However, closely related genera possess ovipositors which are very similar. Examples of this similarity are shown in *Agalliopsis* and *Aceratagallia; Macropsis* and *Oncopsis; Oncometopia, Homalodisca* and *Aulacizes; Cicadella* and *Graphocephala; Nephotettix* and *Driotura; Dorycephalus* and *Hecalus; Helochara* and *Dræculacephala; Jassus* and *Tinobregmus; Balclutha* and *Eugnathodus;* and *Dikraneura, Empoasca* and *Typhlocyba,* all in the tribe Typhlocybini, which is very clearly set apart by the characters of the ovipositor.

Between the species of well-defined genera there is an indisputable generic similarity. The characters of size, chitinization and number of teeth vary, but the characters of general shape, and shape and arrangement of teeth seem to be constant within the genus. Examples of generic similarity are shown in *Idiocerus, Macropsis, Kolla, Dræculacephala, Platymetopius, Deltocephalus, Balclutha,*

Empoasca, and many others. In the admittedly loose and complex genus *Euscelis* the ovipositors show the wide range of forms that would be expected, and the same condition might be found in other genera of equal complexity.

Finally, we find constant characters of specific value in the ovipositor. The ovipositors of seventeen individuals of *Cicadella hieroglyphica* (Say), representing as wide a geographical range and as many color varieties as are to be found in our duplicate collection, were examined and found to be constant in the characters given, which are sufficient to separate it from the other species of the genus examined. Several specimens each of *Graphocephala coccinea* (Forster) and *Oncometopia lateralis* (Fabricius) were examined in the same way and their characters also found to be constant. Hence it can safely be concluded that characters of specific value, constant within the range of the species, are found in the ovipositors of the Cicadellidæ. It is also true that these characters are accessible to the general worker and should not be neglected by him in a taxonomic study in this family.

BIBLIOGRAPHY.

1878—Packard: Guide to the Study of Insects
1898—Marlatt: Periodical Cicada. U. S. Dept. of Agr., Bull. No. 14, n. s.
1909—Packard: Textbook of Entomology
1910—Stough: Hackberry Psylla. Kansas U. Sci. Bull., vol. V, No. 9, p. 121.
1917—Van Duzee: Catalogue of Hemip. of N. A.
1918—Newell: Comp. Morph. of the Genitalia of Insects. Ann. Ent. Soc. Am., vol. XI, No. 2, p. 109.
1919—Kornhauser: Sexual Characters of Thelia. Journ. of Morph., vol. 32, No. 3, p. 531.
1919—Walker: Structure of Orthop. Insects. Ann. Ent. Soc. Am., vol. XII, No. 4, p. 267.
1920—Lawson: Cicadellidæ of Kansas. Kansas U. Sci. Bull., vol. XII, No. 1.
1921—Hilsman: Ovipositor of the Cicada. Thesis MS., University of Kansas.

PLATE XXI.

1. Ventral view of abdomen of female.
2. Dorsal view of abdomen of female.
3. Cross section through abdomen.
4. Dorsal view of segment nine, showing attachment of ovipositor.
5. Ventral view of segment nine, showing attachment of ovipositor.
6. Cross section through ovipositor, showing relative position of valves.
7. Valve I, showing attachment to eighth sternum.
8. Detached portion of valve I, showing attachment to ninth pleuron.
9. Valve II (upper) and valve I (lower), showing attachment to ninth sternum.

PLATE XXI.

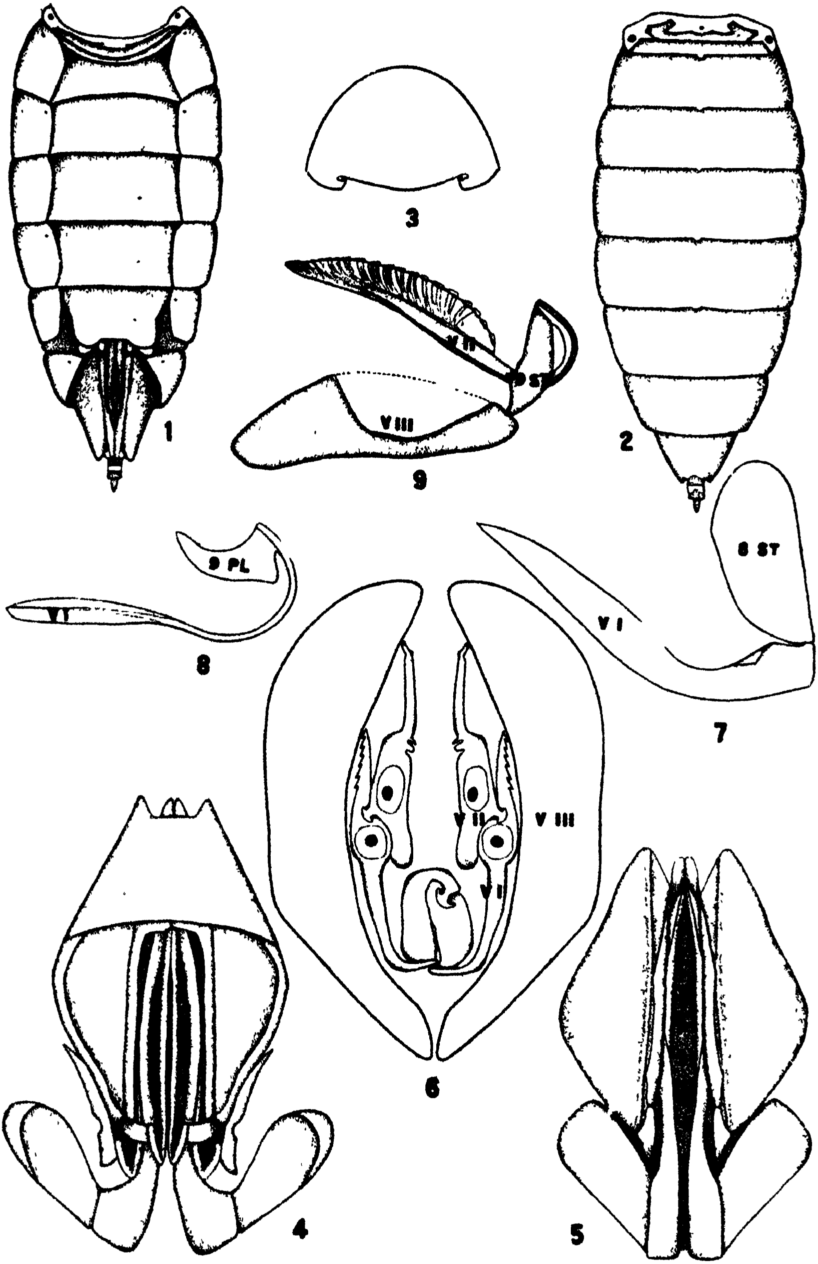


PLATE XXII.

1. *Idiocerus pallidus* Fitch.
2. *Agalliopsis novella* (Say).
3. *Oncometopia undata* (Fabricius).
4. *Oncometopia lateralis* (Fabricius).
5. *Homalodisca triquetra* (Fabricius)
6. *Aulacizes irrorata* (Fabricius).
7. *Cicadella hieroglyphica* (Say).
8. *Cicadella circellata* (Baker).
9. *Graphocephala coccinea* (Forster)
10. *Helochara communis* Fitch.
11. *Draeculacephala mollipes* (Say).
12. *Draeculacephala reticulata* (Signoret).
13. *Kolla bifida* (Say).
14. *Kolla hartii* (Ball).

PLATE XXII.

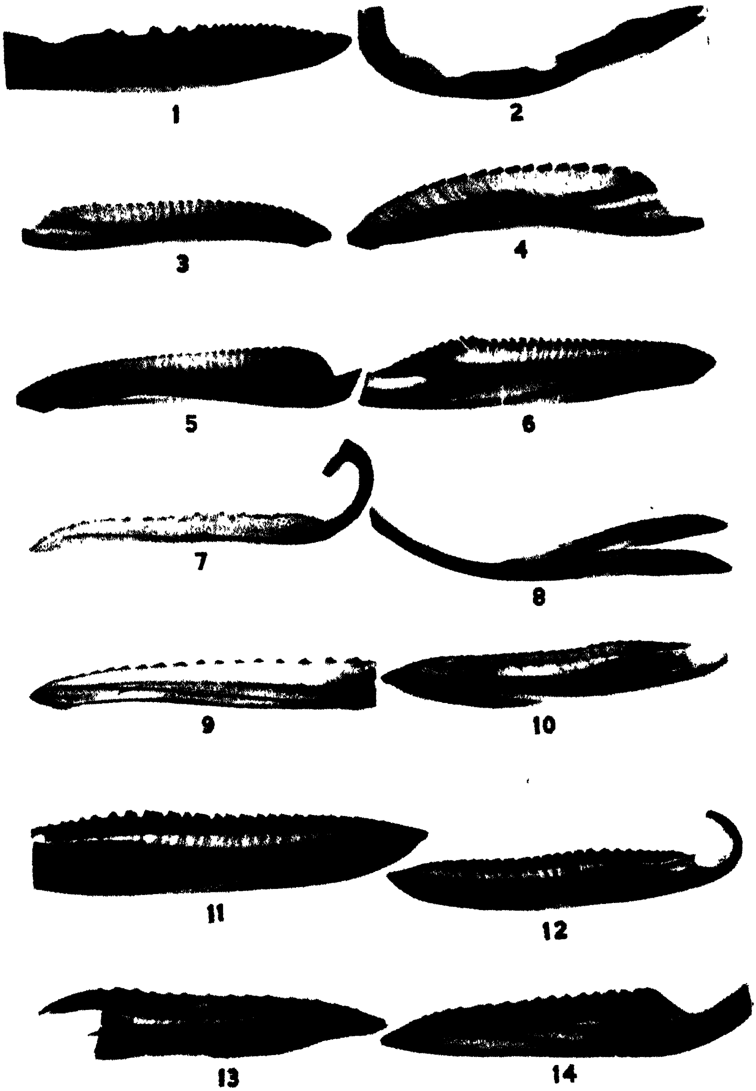


PLATE XXIII.

1. *Gypona octo-lineata* (Say)
2. *Xerophloea viridis* (Fabricius)
3. *Xestocephalus pulicarius* Van Duzee.
4. *Scaphoideus immistus* (Say)
5. *Platymetopius acutus* (Say)
6. *Platymetopius frontalis* Van Duzee
7. *Mesamia vitellina* (Fitch)
8. *Deltocephalus inimicus* (Say)
9. *Deltocephalus flavicosta* Stal
10. *Driotura gammaroides* (Van Duzee)
11. *Euscelis exitiosus* (Uhler).
12. *Euscelis striolus* (Fallen)
13. *Euscelis comma* (Van Duzee)
14. *Euscelis bicolor* (Van Duzee).

PLATE XXIII.

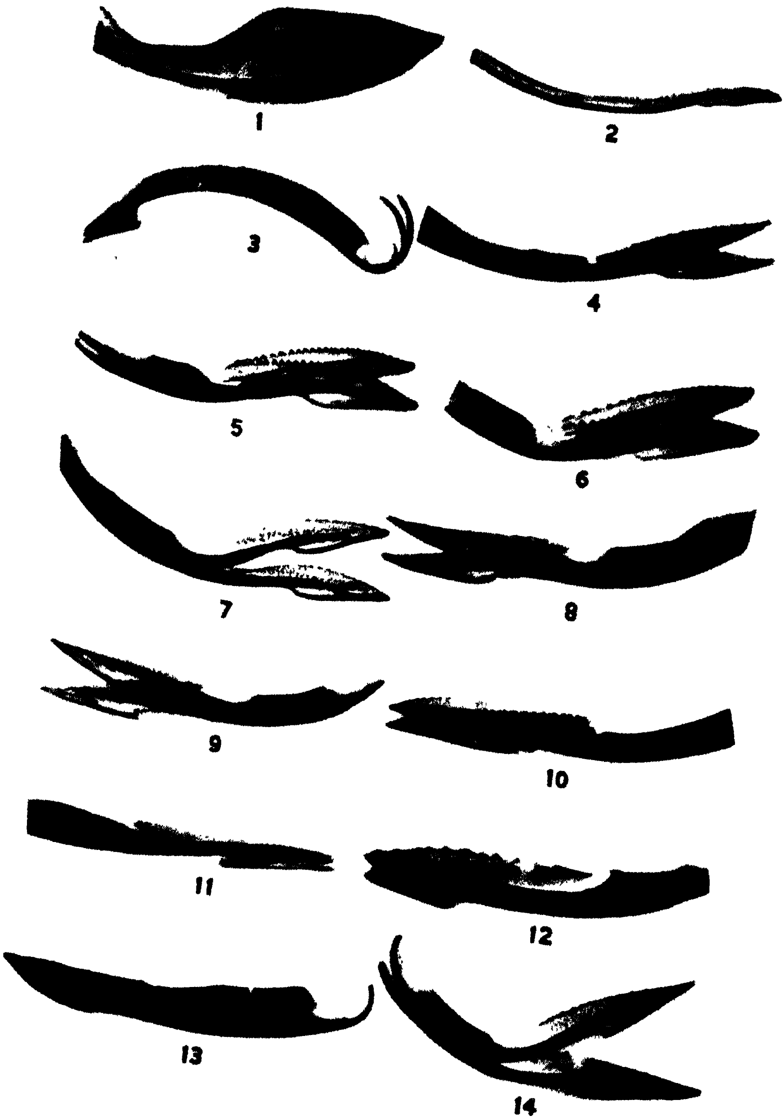


PLATE XXIV

1. *Eutettix cinctus* Osborn and Ball
2. *Eutettix strobi* (Fitch).
3. *Phlepsius spatulatus* Van Duzee
4. *Phlepsius excultus* (Uhler)
5. *Phlepsius irroratus* (Say).
6. *Acinopterus acuminatus* Van Duzee
7. *Chlorotettix spatulatus* Osborn and Ball
8. *Chlorotettix galbanatus* Van Duzee
9. *Cicadula punctifrons* var *repleta* Fieber.
10. *Balclutha punctata* (Thunberg)
11. *Balclutha impicta* (Van Duzee)
12. *Eugnathodus abdominalis* (Van Duzee)
13. *Dikraneura abnormis* (Walsh).
14. *Empoasca obtusa* Walsh.

PLATE XXIV.

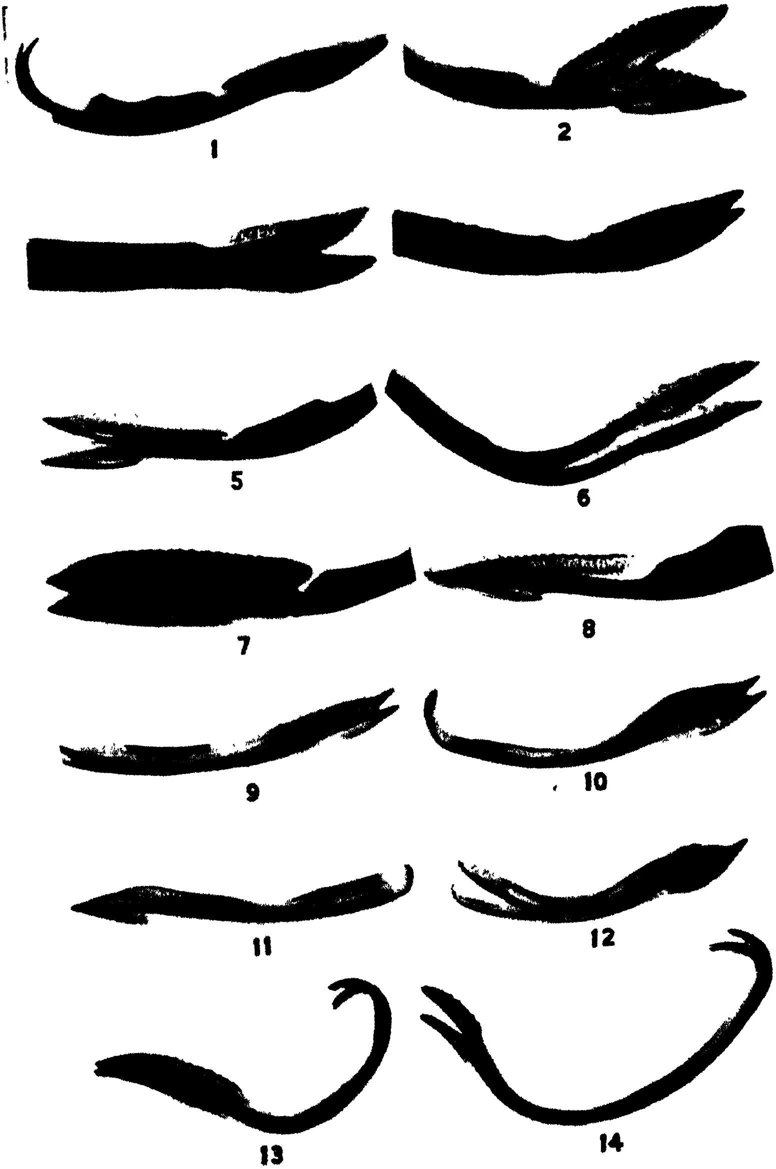


PLATE XXV.

1. *Agalliopsis novella* (Say)
2. *Aceratagallia uhleri* Van Duzee.
3 *Idiocerus snowi* Gillette and Baker
4. *Idiocerus ramentosus* (Uhler)
5. *Idiocerus pallidus* Fitch
6. *Idiocerus duzeei* Provancher
7. *Idiocerus verticis* (Say).
8. *Idiocerus scurra* (Germar).
9 *Idiocerus nervatus* Van Duzee
10 *Bythoscopus apicalis* (Osborn and Ball).
11. *Bythoscopus misellus* (Stal).

PLATE XXV

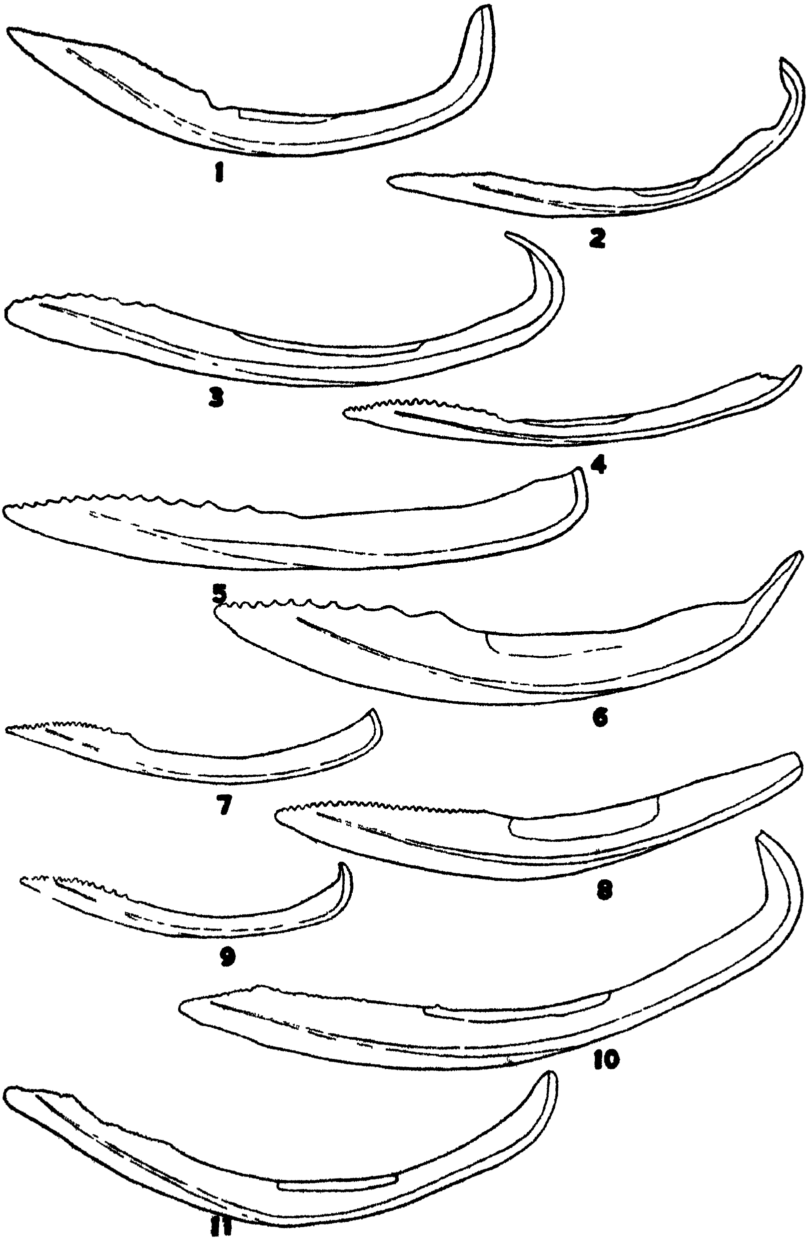


PLATE XXVI

1 *Macropsis viridis* (Fitch)
2 *Macropsis suturalis* (Osborn and Ball)
3 *Oncopsis distinctus* (Van Duzee)
4 *Oncometopia undata* (Fabricius)
5 *Oncometopia lateralis* (Fabricius)
6 *Homalodisca triquetra* (Fabricius)
7 *Aulacizes irrorata* (Fabricius)
8 *Cicadella circellata* (Baker)
9 *Cicadella hieroglyphica* (Say)

PLATE XXVI.

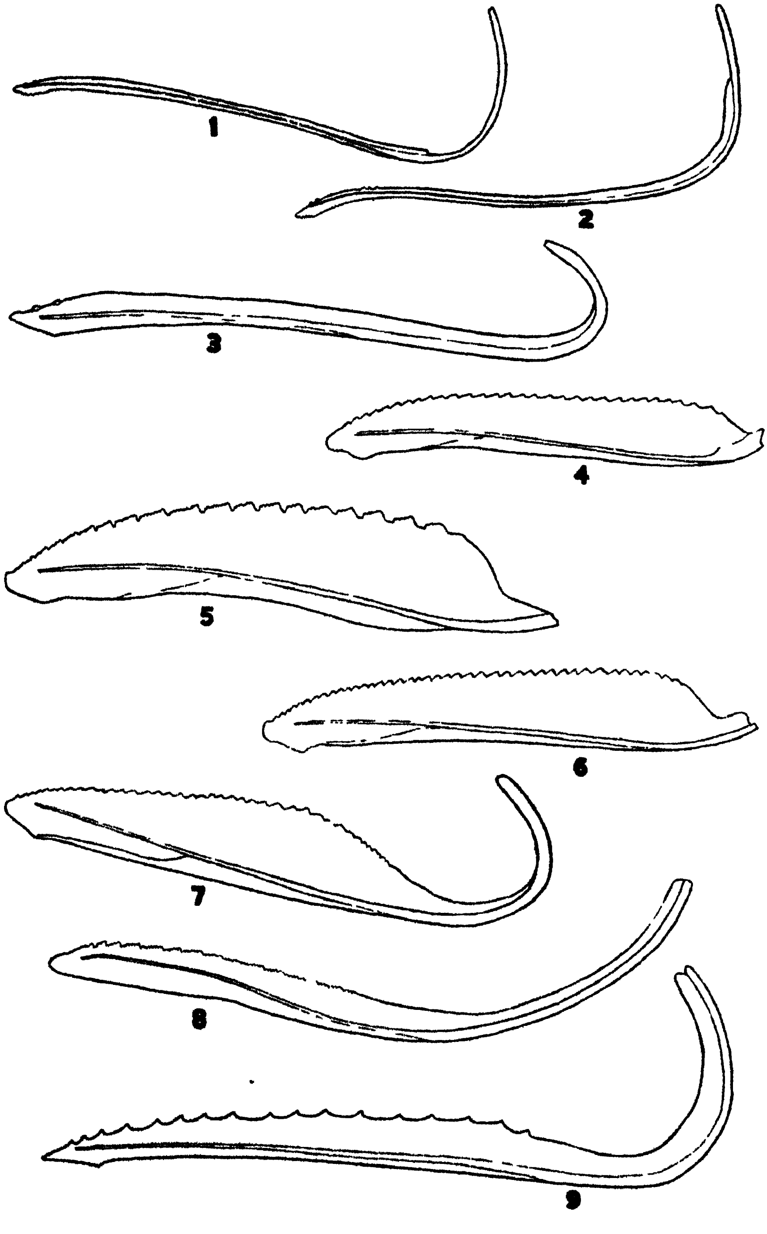


PLATE XXVII.

1. *Dræculacephala noveboracensis* (Fitch).
2. *Dræculacephala mollipes* (Say).
3. *Dræculacephala reticulata* (Signoret).
4. *Errhomenellus montanus* Baker.
5. *Helochara communis* Fitch.
6. *Pagaronia tripunctata* (Fitch).

PLATE XXVII.

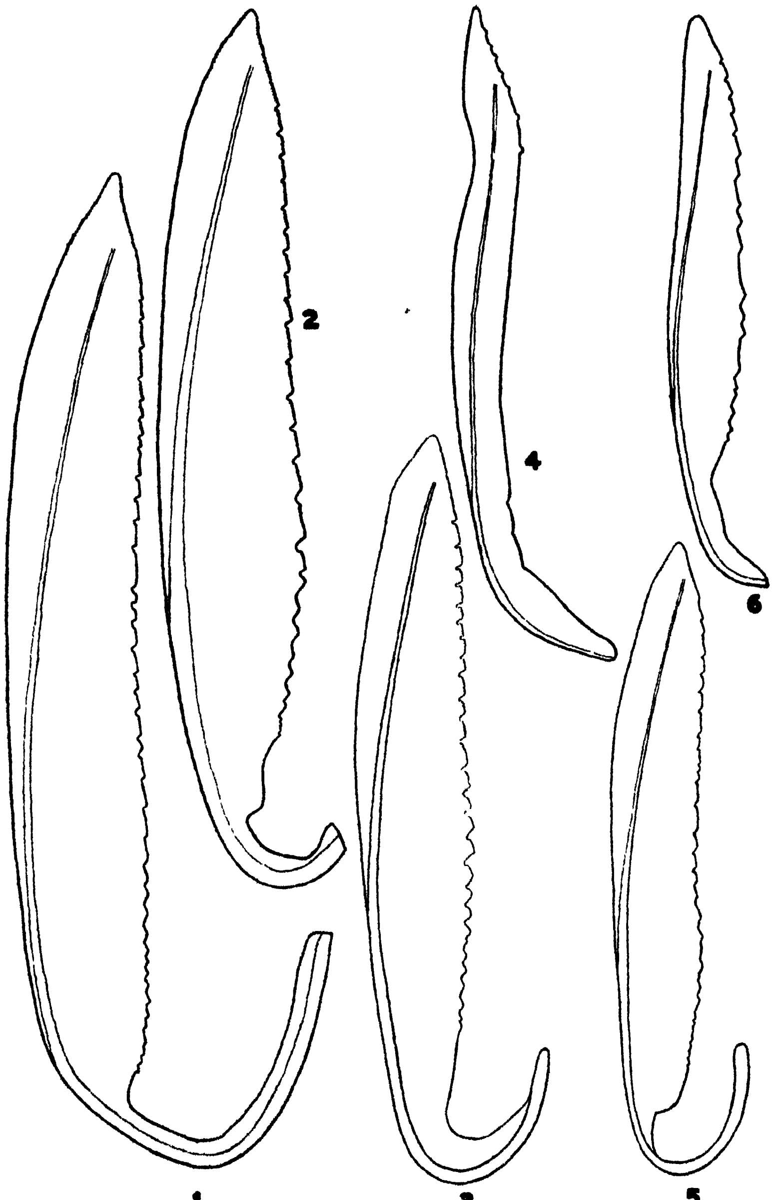


PLATE XXVIII.

1. *Kolla hartii* (Ball).
2. *Kolla geometrica* (Signoret).
3. *Kolla bifida* (Say).
4. *Graphocephala coccinea* (Forster).
5. *Gypona bimaculata* Spangberg.
6. *Gypona angulata* Spangberg.
7. *Gypona pectoralis* Spangberg.
8. *Gypona octo-lineata* (Say).

PLATE XXVIII

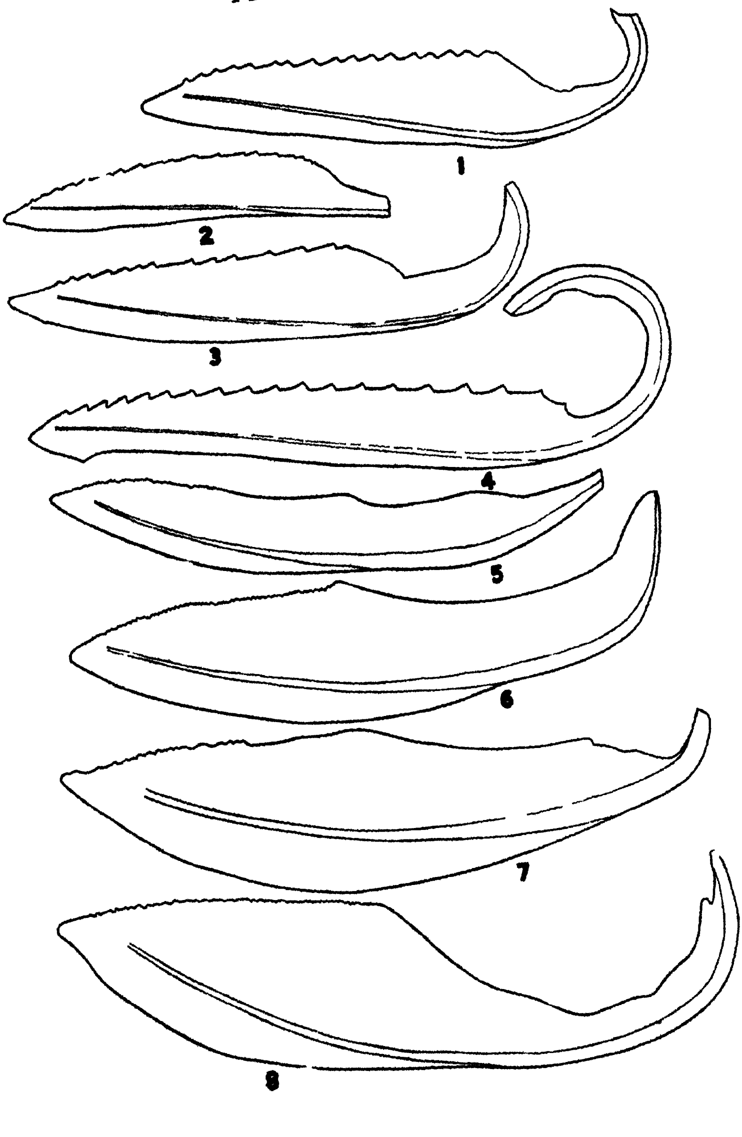


PLATE XXIX.

1. *Xestocephalus pulicarius* Van Duzee.
2. *Xerophlœa viridis* (Fabricius).
3. *Stroggylocephalus agrestis* (Fallen).
4. *Dorycephalus platyrhynchus* Osborn.
5. *Memnonia consobrina* Ball.
6. *Spangbergiella mexicana* Baker.
7. *Parabolocratus flavidus* Signoret.
8. *Hecalus lineatus* (Uhler).
9. *Mesamia straminea* (Osborn).
10. *Mesamia vitellina* (Fitch)
11. *Aligia jucunda* (Uhler).

PLATE XXIX.

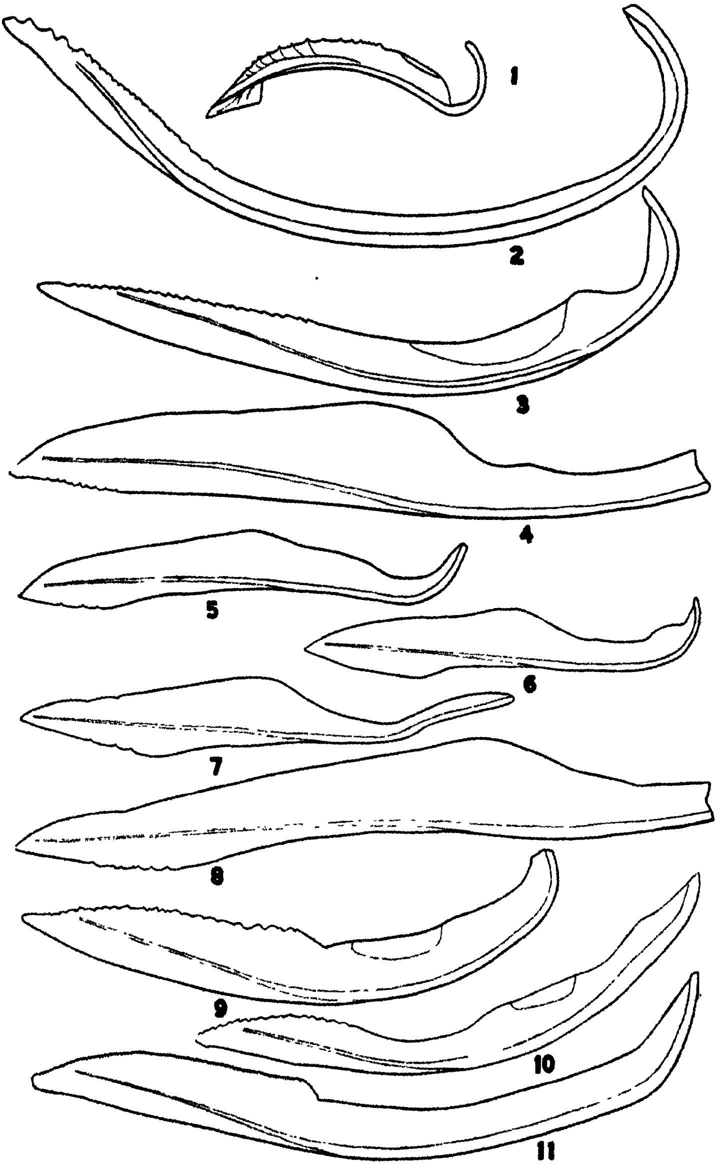


PLATE XXX.

1. *Scaphoideus scalaris* Van Duzee.
2. *Scaphoideus immistus* (Say).
3. *Platymetopius acutus* (Say).
4. *Platymetopius cinereus* Osborn and Ball.
5. *Platymetopius frontalis* Van Duzee.
6. *Deltocephalus reflexus* Osborn and Ball.
7. *Deltocephalus weedi* Van Duzee.
8. *Deltocephalus inimicus* (Say).
9. *Deltocephalus flavicosta* Stal.
10. *Deltocephalus debilis* Uhler.
11. *Deltocephalus parvulus* Gillette.
12. *Deltocephalus collinus* Boheman

PLATE XXX.

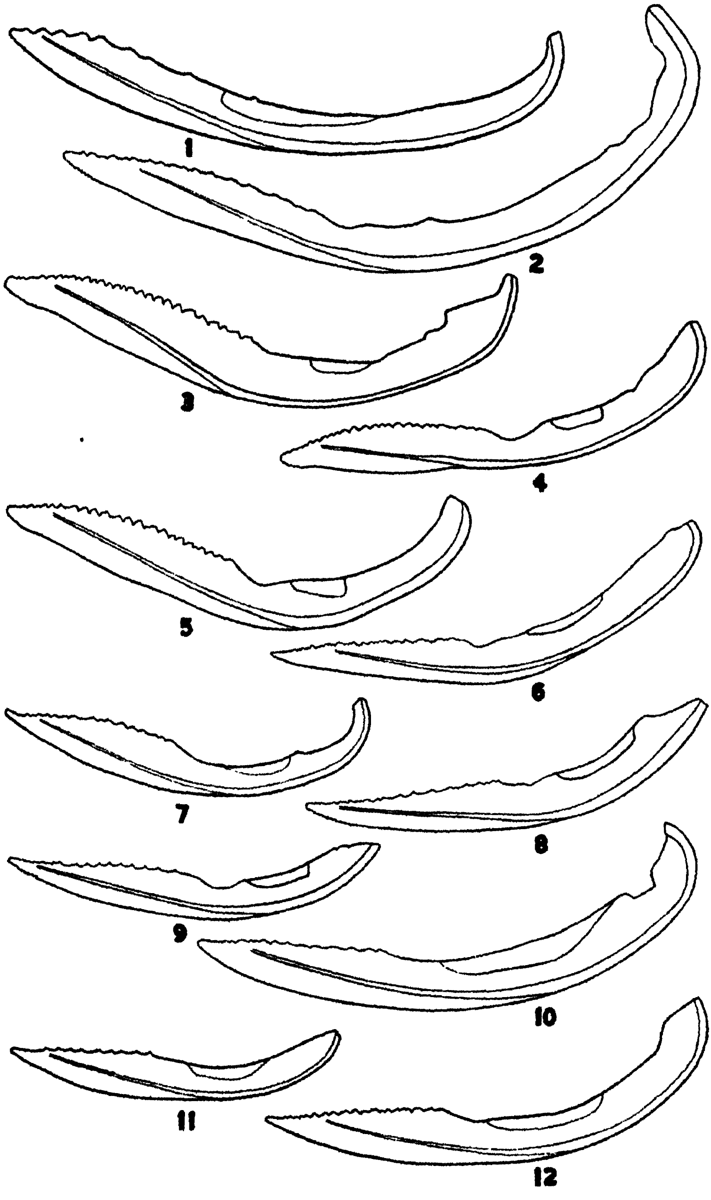


PLATE XXXI.

1. *Euscelis exitiosus* (Uhler).
2. *Euscelis striolus* (Fallen).
3. *Euscelis anthracinus* (Van Duzee)
4. *Euscelis comma* (Van Duzee).
5. *Euscelis curtisii* (Fitch).
6. *Euscelis bicolor* (Van Duzee).
7. *Eutettix strobi* (Fitch).
8. *Eutettix cinctus* Osborn and Ball.
9. *Aconura argenteolus* (Uhler).
10. *Nephotettix curtipennis* (Gillette and Baker).
11. *Driotura gammaroides* (Van Duzee).

PLATE XXXI.

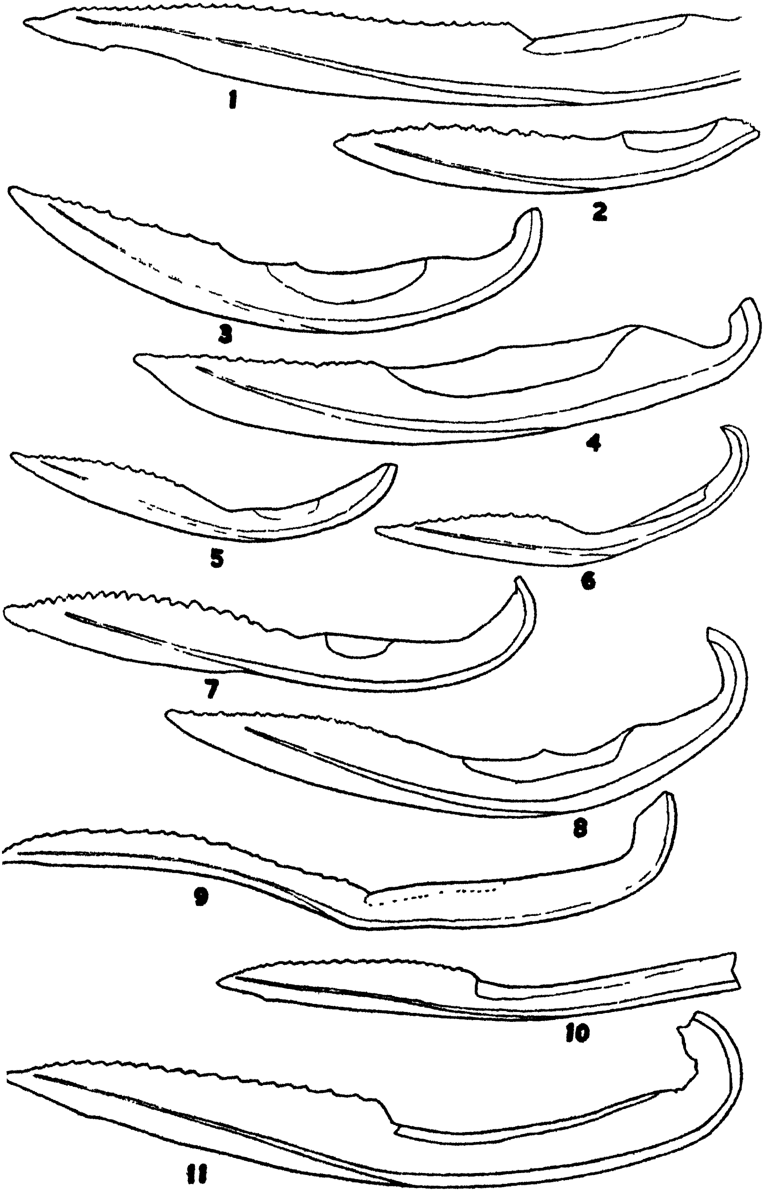


PLATE XXXII.

1. *Acinopterus viridis* Ball.
2. *Acinopterus angulatus* Lawson
3. *Acinopterus acuminatus* Van Duzee.
4. *Thamnotettix longulus* Gillette and Baker.
5. *Thamnotettix clitellarius* (Say).
6. *Chlorotettix spatulatus* Osborn and Ball.
7. *Chlorotettix galbanatus* Van Duzee.
8. *Phlepsius irroratus* (Say).
9. *Phlepsius excultus* (Uhler).
10. *Phlepsius spatulatus* Van Duzee.

PLATE XXXII.

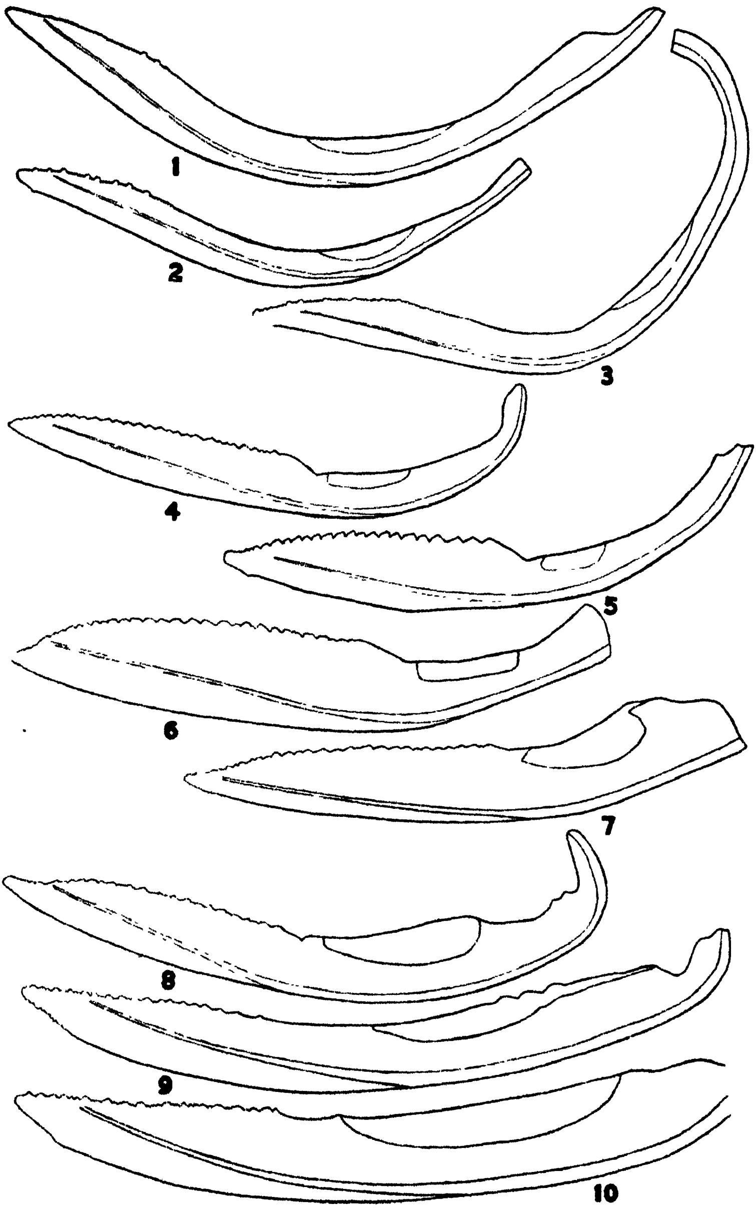
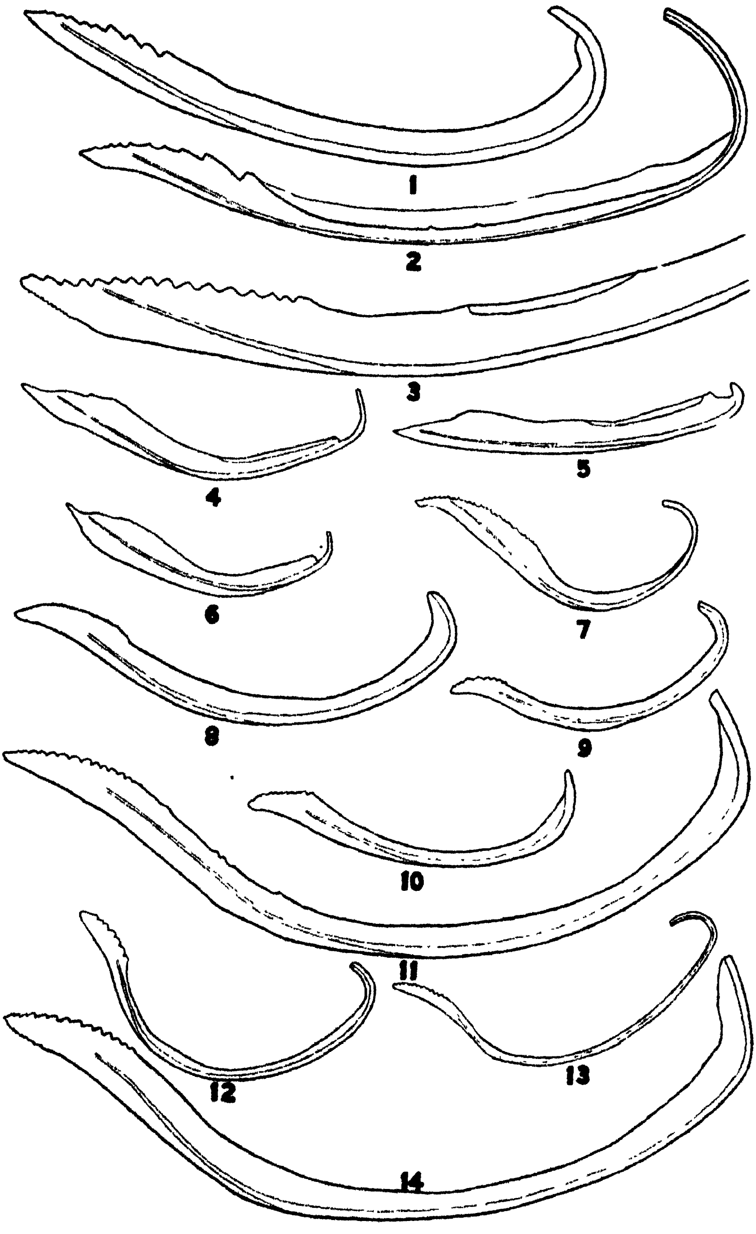


PLATE XXXIII.

1. *Tinobregmus vittatus* Van Duzee.
2. *Jassus olitorius* Say.
3. *Cicadula punctifrons* var. *repleta* Fieber.
4. *Balclutha punctata* (Thunberg).
5. *Balclutha impicta* (Van Duzee).
6. *Eugnathodus abdominalis* (Van Duzee).
7. *Dikraneura abnormis* (Walsh).
8. *Erythroneura tricincta* Fitch.
9. *Erythroneura vulnerata* Fitch.
10. *Empoasca trifasciata* Gillette.
11. *Empoasca smaragdula* (Fallen).
12. *Empoasca obtusa* Walsh.
13. *Empoasca mali* (Le Baron).
14. *Empoasca livingstoni* Gillette.

PLATE XXXIII.



INDEX.

THE

KANSAS UNIVERSITY

SCIENCE BULLETIN

VOL. XIV, NO. 9—OCTOBER, 1922.

(Whole Series, Vol XXIV, No. 9.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 9.

Life History Notes on Two Species of Saldidæ (Hemiptera) Found in Kansas.*

BY GRACE OLIVE WILEY.

THE family characteristics of the saldids are so well known that a description need not be given here. A few brief notes on certain Kansas species, however, may be of interest.

Nymphs in the third and fourth instars were taken June 1, 1920, along a little ravine leading to a pond or pool which contained water only during the spring and early summer when rains were frequent. This little freshet and pond were in a small pasture just outside the city limits of Chanute, Kan. Here, within a few blocks of home, I found two different species of saldids, though in not very plentiful numbers.

Knowing that no Kansas saldid had yet been reared, I captured all the lively little fellows I could and sat about the task of rearing them. One was a large black species, the other a much smaller species.

THE LARGE BLACK SALDID.

Saldula major (Prov.).

June 12 there were two adults, and by June 18 the others had reached the adult state and were mating. June 21 I found twelve newly laid eggs on a blade of grass. These hatched July 3. With what pleasure and interest these active little fellows were watched! The adults were shy, but very inquisitive, and when food was placed in their dish they were always ready to run up and take a look at it, curiosity-bent, it seemed; or when removing food that had been given to them the day previous, they were equally curious to see what was going on. Not so with the smaller species; they were always trying to get away or hide.

*I wish to thank Dr. H. B. Hungerford for his help and kindly criticism and for the loan of a binocular from the University.

The nymphs liked to stay hidden most of the time, but would come out and feed quite readily. It was interesting to see one of the little fellows prodding around an insect for a soft spot in which to insert its needlelike beak. Nor does it disturb one of them in the least to remove the insect and place same under the binocular to watch the process of feeding.

The newly emerged nymphs, either from the egg or molt, are very bright red in color, with eyes, antennæ, beak and legs very dark. They become dark, however, in a very short time, except the nymphs which emerge from the eggs; these are red for more than a day. The adults are very pale pink or yellowish when they first emerge, with eyes, antennæ, beak and legs very dark. They become dull black in a short time, with rather pale, obscure markings on the wing covers.

DESCRIPTION OF STAGES.

See plate XXXIV.

THE EGG.

Size. Length about 1.2 mm.; width across widest part, .3 mm.

Color. Pearly white and transparent when first laid, becoming yellow in color three days later. The fourth-day egg shows red eyelike spot, and two days later the entire egg becomes red in color; another day later, making seven days from time egg was laid, it is blood red with very dark, eyelike spots. When nine days old the egg is orange red, and on the twelfth day the nymph emerges. A few hours before hatching the egg becomes pale or whitish in color.

Shape. General shape shown by drawing. It is elongate, larger and more broadly rounded at one end, tapering and much smaller at the other end, with dorsal part arched.

FIRST INSTAR.

Size. Total length of one day-old nymph, about 1.1 mm.; width across abdomen, .6 mm.

Color. Red to light reddish brown, with dark spot on fifth abdominal segment, on the median line of the dorsal part. Eyes, legs, beak and antennæ black.

Structural peculiarities. Rostrum reaching to the apex of the posterior coxæ. Antennæ four-segmented, last joint darker in color and larger than the others. Tarsi one-jointed. Length of first stage, four days.

SECOND INSTAR.

Size. Length about 1.8 mm.; width across abdomen about 1 mm.

Color. Dark reddish brown on dorsal part, with ventral part red. Venter very dark brown, nearly black.

Structural peculiarities. Antennæ four-segmented, with last segment larger than the other segments. Rostrum reaching to the base of the posterior coxæ. Antennæ and legs covered with very fine black hairs, some longer and more sparsely placed than the others.

Shape. A trifle stouter than first-instar nymph.

THIRD INSTAR.

Size. Length from 2.25 to 2.5 mm.; width across abdomen from 1.3 mm. to 1.4 mm.

Color. Color on the dorsum very dark brownish black, with ventral parts brown.

Shape. Much the same as the second instar, only much stouter.

FOURTH INSTAR.

Size. Length, 3.25 mm. to 3.5 mm.; width across abdomen, 1.9 mm. to 2 mm.

Color. Shining black over entire part; most of the ventral part black except the throat and around the legs, which is slightly paler in color, also the anterior and lateral parts of the carina or keel of the abdomen, which is whitish in color; venter very dark.

Shape. Decidedly stouter than third instar and wing pads now much in evidence.

Structural peculiarities Rostrum reaching to the apex of the posterior coxæ. Ventral part of the abdomen carinated. Antennæ long, rather stout, and covered, as in the third instar, with fine black hairs.

FIFTH INSTAR.

Size. Length from about 4.5 mm to 4.8 mm ; width across abdomen at widest part, 2.5 mm. to 2.625 mm

Color. All of dorsum shining black in color. Ventral parts same as in fourth instar, as are also the antennæ and legs. Second joint of antennæ decidedly longer and more slender than any of the other joints. Rostrum reaching to the base of the posterior coxæ. Eyes emarginate. Wing pads reaching to the apex of the second abdominal segment.

THE ADULT.

Size. Female: length of the body, not including the antennæ and legs, 6.5 mm. to 6.875 mm.; width, 2.8 to 3 mm. Male: length, 6.25 mm.; width, 2.625 to 2 mm.

Color. Entire insect dull black with a few obscure, pale markings. Body oblong, oval. Ocelli slightly apart. Head long and tapering to the front. Eyes large, emarginate and strongly exserted. Scutellum rather flat with a depression in center of disk. The posterior lateral margins of pronotum and the anterior margins of hemelytra slightly reflexed. Rostrum long and slender, first joint short and thick, second joint very long, the tip reaching to the base of the middle coxæ; third joint reaching to the base of the posterior coxæ. Color of beak black and shining, with tip slightly paler. Antennæ very black, stout and long; basal joint stout and considerably shorter than third or fourth joints; second joint very long and slender; last two joints nearly the same length; last joint slightly longer than the next to last. Body covered with sparse, closely appressed, golden pubescence. Membrane furnished with four areas.

Oviposition. The eggs are deposited at the base of grass blades, or are thrust with the sharp ovipositor through the blades of grass. (See plate XXXIV.)

Incubation. Twelve days.

Maturity. Adults come from eggs in twenty-eight days.

General notes. Length of first instar, four days; of second instar, three days; of third instar, three days; of fourth instar, two or three days; of fifth instar, four days. No ocelli are present in any of the nymphal stages.

MEASUREMENTS IN MILLIMETERS OF NYMPHS AND ADULTS OF LARGE SPECIES KANSAS SALDID.

Instar	Body measurements, m m						Leg measurements, m m.								
							Fore leg.			Middle leg.			Hind leg		
	Length	Width	Across eyes	Width, shoulder	Length, antennæ	Beak	Femur	Tibia	Tarsi	Femur	Tibia	Tarsi	Femur	Tibia	Tarsi
1st	1 1	6	4	5	6	7	3	25	1	35	3	15	4	4	2
2d	1 8	1 0	7	75	1 0	1 1	5	4	2	5	45	25	6	7	3
3d	2 5	1 4	9	1 0	1 6	1 6	6	5	25	7	6	3	8	1 0	4
4th	3 5	1 9	1 1	1 3	2 0	2 0	9	7	3	1 0	1 0	4	1 2	1 5	6
5th	4 8	2 5	1 4	1 9	2 7	2 7	1 2	1 0	5	1 5	1 2	6	1 6	2 2	9
6th ♀	6 5* 6 75†	2 8	1 5	2 0	3 5	3 0	1 5	1 3	7	1 6	1 6	8	2 0	3 0	1 25
6th ♀	6 0* 7 0†	3 0	1 5	2 25	3 5	3 5	1 8	1 4	7	1 8	1 6	7	2 2	3 0	1 25
6th ♂	6 0	2 8	1 5	2 0	3 5	3 0	1 5	1 4	7	1 8	1 6	8	2 0	3 0	1 25

* Venter † Elytra

These measurements were made with micrometer, Bausch and Lomb binocular, 6.4 oculars, 55 mm. objectives By placing millimeter ruler under binocular, micrometer measured ten lines to the millimeter Thus: 10 lines micrometer — 1 mm

SMALL SPECIES OF KANSAS SALDID.

*Saldula pallipes Fabr. (?)**

From adults reared from nymphs captured June 1, 1920, along with nymphs of a large black species of saldid, I obtained, June 23, several clear creamy-white eggs, thrust in the stems and blades of grass growing in the jars in which these saldids were confined. These were not the first eggs laid, however, as I also found several small nymphs, but the eggs had been so cleverly hidden that I had not found them. These eggs hatched July 1 to 3, and became adults sixteen days later. Eggs from this second generation hatched August 13 and August 20, becoming adults also in from sixteen to seventeen days from the time the nymphs emerged from the eggs.

On the 28th of July I went to Texas to join my husband, who was in the employ of an eastern oil company. I could not think of

*Mr Hungerford says this American species is not the same as the European species.

giving up the life histories of the two species of saldids I was rearing, so placing all the little glasses containing them in a covered basket, I took them with me. No doubt the people on the train thought I was taking a lunch with me, or perhaps a pet dog or cat! I wonder how many ladies would have slept well that night had they known that the basket contained live bugs!

In all the rearings I fed dead flies and other soft-bodied insects, chiefly mirids (capsids) and cicadellids (jassids), as these were usually easier to obtain in large numbers either by sweeping or at the light at night.

DESCRIPTION OF STAGES.

See Plate XXXV

THE EGG.

Size. Length about .6 mm.; width, .15 mm.

Color. Clear, creamy-white when first laid, changing to yellow. Duration of egg stage, 8 to 10 days.

Shape. Elongate-cylindrical; one end broadly rounded and considerably larger than the other end. Dorsal part arched.

FIRST INSTAR

Size. Length of body about .8 mm.; width of abdomen at widest part, .4 mm.

Color. Greenish brown with dark spot on the dorsum of abdomen along median line.

Structural peculiarities. Mostly head, with large, reddish eyes; four-segmented slender antennæ, fourth segment stouter than the others Duration of first instar, four days.

SECOND INSTAR.

Size. Length, 1. mm.; width, .6 mm.

Color. Light green with eyes and antennæ dark reddish brown. Dark spot on the dorsum of abdomen.

Shape. Much the same as first instar only stouter. Duration of instar, three days.

THIRD INSTAR.

Size. Length, 1.5 mm.; width, .8 mm.

Color. Head and thorax yellowish; third and fourth abdominal segments dark green with spot on the dorsum orange yellow; remainder of abdomen yellowish green. Eyes and tip of antennæ dark brown.

Structural peculiarities. Tarsi segmented as in all the other instars; rostrum reaching to the posterior coxæ. Duration of third instar, three days.

FOURTH INSTAR.

Size. Length of body, 2 mm.; width of abdomen, 1.2 mm.

Color. Grayish flecked with brown.

Shape. Nymph much stouter than in the third instar, and wing pads reaching to the base of the second abdominal segment. Beak reaching to the apex of the posterior coxæ. Duration of fourth instar, 3 days.

FIFTH INSTAR.

Size. Total length, 2.7 mm. to 3 mm.; width, 1.5 mm. to 1.6 mm. in widest portion.

Color. Grayish brown speckled or mottled.

Structural peculiarities. Antennæ slender, four-segmented as in the other instars; fourth segment larger and stouter than the others; second segment longest and very slender; body, legs and antennæ covered with sparse, short, brown pubescence. Rostrum reaching to the apex of the posterior coxæ. Wing pads reaching to base of third abdominal segment. Duration of fifth instar, three days.

THE ADULTS.

Size. Length of the entire body, not including antennæ and legs: Female: 3.5 mm. to tip of abdomen; 3.9 to 4 mm. to tip of hemelytra; width of abdomen across the widest part, 1.6 mm. to 1.7 mm. Male: length 3 mm. to tip of hemelytra; width, 1.5 mm.

Description. Oblong-ovate, black above, closely invested with minute yellow pubescence; eyes large, rather oblong, brown, and very prominent. Ocelli reddish and slightly apart. Clypeus and tylus straw yellow; rostrum black and reaching upon the posterior coxæ. Ventral part body jet black; sternum and pectus closely appressed with silvery-white pubescence. Legs pale with dark markings. Pronotum and scutellum rather flat, disk of pronotum slightly elevated and with a minute depression in center of disk. Scutellum a little longer than broad. Hemelytra brownish black with grayish-white markings. Clavus with oblong spot at the apex. Corium with two squarish spots near the upper, outer margin and two very small spots on the posterior margin near membrane. Embolium mostly grayish white, there usually being three dark spots along the median nerve connected by a dark-colored line or nerve. Membrane gray with dark veins and furnished with four areas, each having one or more smoky spots therein. Antennæ slender, four-segmented; basal segment stoutest, dark underneath, pale above; second segment very slender and almost twice the length of the first segment; third and fourth segments about equal in length and stouter than the second.

MEASUREMENTS IN MILLIMETERS OF NYMPHS AND ADULTS OF SMALL SPECIES KANSAS SALDID.

Instar	Body measurements, mm.						Leg measurements, mm.								
							Fore leg.			Middle leg.			Hind leg.		
	Length	Width	Across eyes	Width, shoulder	Length, antennæ	Beak	Femur	Tibia	Tarsi	Femur	Tibia	Tarsi	Femur	Tibia	Tarsi
1st	.8	4	.350	.3	4	4	125	.12	065	15	.125	.070	16	25	080
2d	1.0 to 1 1	.6	.4 .5	45 .525	5	.5 6	.2	2	1	3	2	125	3	4	175
3d	1.5	8	6	.7	8	9	4	35	1	4	35	.15	5	6	2
4th	1 8 to 2 1	1. 1.2	.6 7	.8 9	1 0	1 1 1 2	4 .5	4	2	5 .6	4 5	2	6 7	7 8	25 3
5th	2 7-2.9 to 3	1 5 1.6	9 1.0	1 25 1 3	1 5	1 5 1 6	7	.6	25	8 9	7	3	.9 1 0	1 1	5
6th ♀	3 5* 4 0† 3 9	1 6 1 7	1 0	1 3	1 6 1 7	1 6 1 7	9	7	3	9	8	35 4	1 1	1 6	6
6th ♂	3 0 to elytra	1 5	.9	1 2	1 5	1 5	7	6	25	8	7	3	9	1 5	5

* Venter. † Elytra.

Measurements made with micrometer same as in large species. 10 lines micrometer = 1 millimeter

PLATE XXXIV.

THE LARGE SALDID.

Saldula major (Prov.).

FIG. 1. Stem of grass with some of the blades removed, showing egg of saldid.

FIG. 2. Under side of grass blade, showing tips of eggs through the opening made by the sharp ovipositor.

FIG. 3. Upper side of the same blade shown in figure 2, showing the eggs and how they were thrust through the leaf.

FIG. 4. Egg in a grass blade and part of the blade torn away to show the tip of the egg on under surface.

FIG. 5. The egg.

FIG. 6. Nymph just out of egg, still in postnatal molt.

FIG. 7. First-instar nymph.

FIG. 8. Second-instar nymph.

FIG. 9. Fourth-instar nymph.

FIG. 10. Third-instar nymph.

FIG. 11. Fifth-instar nymph.

FIG. 12. Adult male.

FIG. 13. Adult female, ventral view.

FIG. 14. Adult female, dorsal view.

PLATE XXXIV.

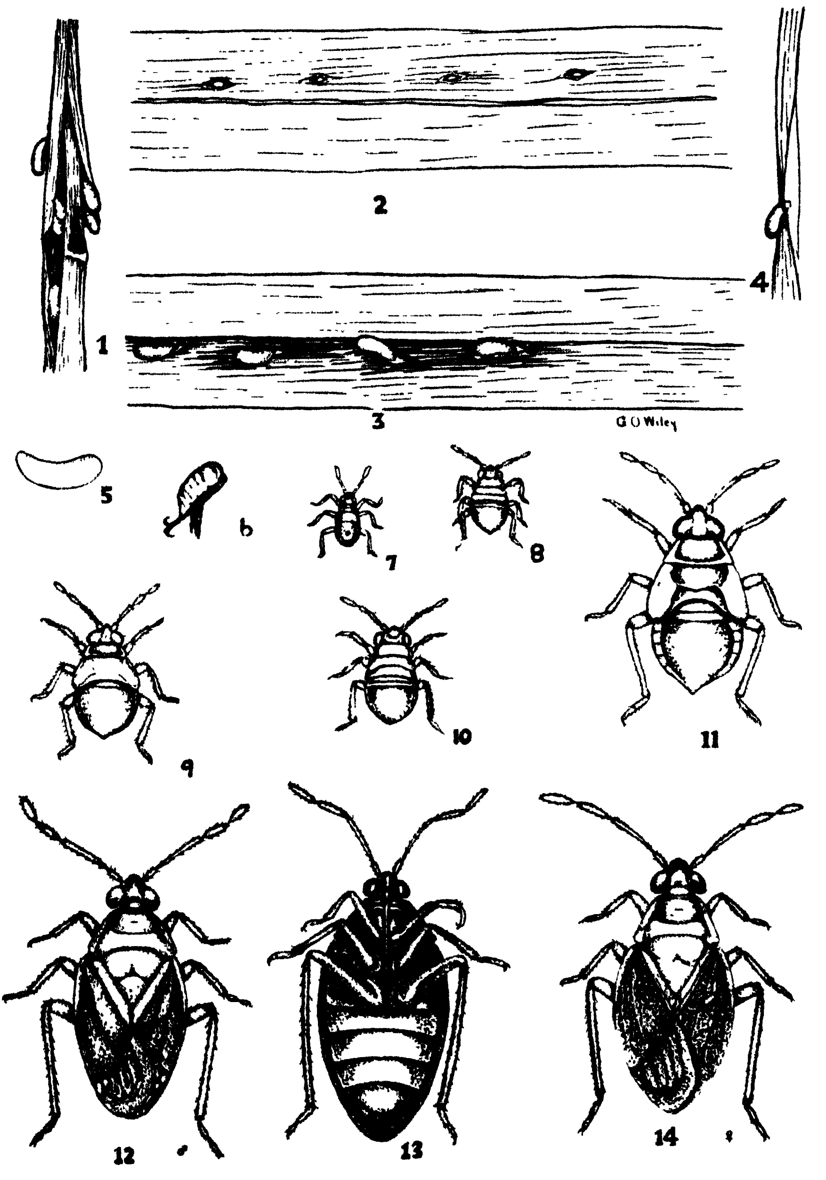


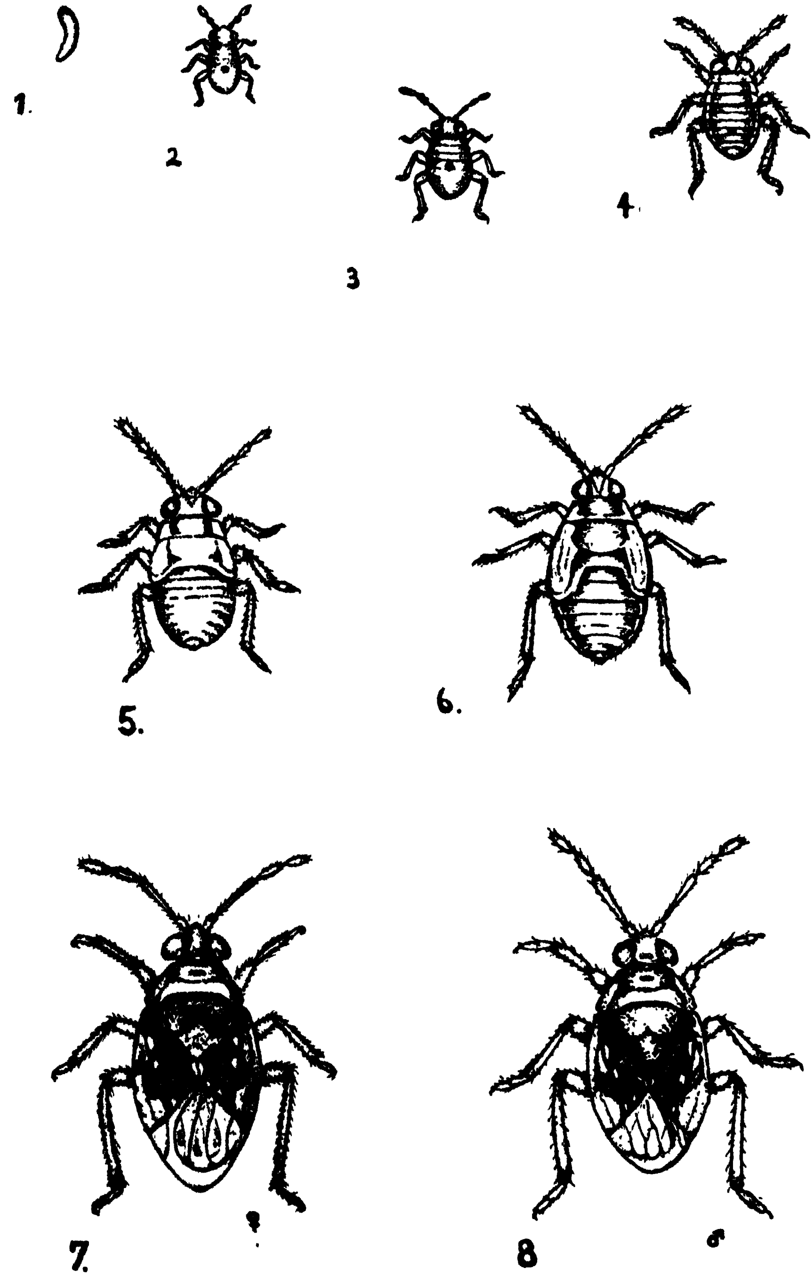
PLATE XXXV.

THE SMALL SALDID.

Saldula pallipes Fabr (?)

FIG. 1. The egg.
FIG. 2. First-instar nymph
FIG. 3. Second-instar nymph.
FIG. 4. Third-instar nymph.
FIG. 5. Fourth-instar nymph.
FIG. 6. Fifth-instar nymph.
FIG. 7. Adult female.
FIG. 8. Adult male.

PLATE XXXV.



THE

KANSAS UNIVERSITY SCIENCE BULLETIN

VOL. XIV, No. 10—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 10.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

Vol. XIV.] October, 1922. [No. 10.

A Problem in the Relation of Temperature to Rate of Insect Development.

By P. A. GLENN,
Chief Inspector, Division of Plant Industry, Illinois State Department of Agriculture, Urbana, Ill.

EVEN the most casual observer is familiar with the fact that low temperatures inhibit growth in plants and animals, that hibernation or death will be evidenced by temperatures approaching freezing, and that high temperatures favor rapid development. It is only in late years that biologists have attempted to ascertain with accuracy the reaction of various plants and animals to different degrees of heat. It has now been quite definitely demonstrated that development will take place only when the temperature is above a certain point, called the zero of development, or the threshold of development; that within a certain range of temperatures above this point the increase in the rate of development is approximately proportional to the rise in temperature; and that under given conditions of high moisture, evaporation and other physical environmental factors aside from heat, there is a temperature constant for each period in development, which is equal to the product of the period by the average temperature above the threshold of development.

This range of temperatures within which the rate of development increases as the temperature rises is bounded at the lower end by the threshold of development, and at the upper end by what I shall call the degree of the maximum rate of development. It is found that at temperatures near the lower limit of this range the rate of development varies somewhat faster than the rate of change in temperature, and at temperatures near the upper limit the rate of development varies somewhat more slowly than the rate of change

of temperatures. These facts are of importance to scientists who wish to ascertain the exact relations between temperature and development, but for practical purposes these slight variations need not be taken into consideration, especially when the varying out-of-door temperatures are to be used as a basis of study.

The problem, therefore, dealt with in this paper may be stated as follows: Given the length in days of the period of development at different average daily temperatures, and the average daily temperatures for each of the periods, to find the threshold of development, the degree of the maximum rate of development, the temperature constant, the effects of temperatures above the degree of the maximum rate of development, and how to make corrections in the temperature factor when the temperature for a part of the time during the period was above the degree of the maximum rate of development.

The problem is a simple one when constant temperatures are used, but with widely varying daily temperatures as a base for study the problem is more difficult, since the average daily temperatures for the periods must be used and in nearly all observations these are influenced by temperatures below the threshold of development or temperatures above the degree of the maximum rate of development.

In this paper the method of procedure will be illustrated by studies on the pupal period of the *Carpocapsa pomonella*, based on observations out of doors on the pupal period of 3,817 pupæ at mean daily temperatures varying from 52.6° F. to 82.6° F.

The following table gives the complete results of the study:

RELATION OF TEMPERATURE TO LENGTH OF PUPAL PERIOD.

Temperature range.	Generation.	Number of observations.	Harmonic average of period.	$\frac{1}{P}$	Average mean daily temperature.	Average daily day-degrees			Total day-degrees.	
						52+	2(87+)	(52+)—2(87+)	52+	(52+)—2(87+)
52–55...	Hib	2	45 5	021	52 6	5 1	......	5.1	236	236
54–55...	Hib	348	35 2	028	55.7	6.8	....	6.8	237	237
56–57....	Hib	976	34 0	.029	56 1	7.0	..	7.0	240	240
58–59....	Hib	243	27 7	.036	58.5	8.6	.....	8 6	241	241
68–69....	First and second,	218	13 8	.072	69 2	17.3	.....	17 3	238	238
70–71....	First and second,	175	12.7	.078	70.7	18.7	.04	18.7–	238	238
72–73 ...	First and second,	221	11 5	.086	73.1	21.1	.24	20.8	242	240
74–75....	First and second,	247	10.7	.093	74.9	22.9	.42	22.5	245	241
76–77...	First and second,	517	10.0	.099	76.7	24.7	.88	23.8	248	239
78–79....	First..........	481	9.4	.105	79.1	27.1	1.63	25.5	256	240
80–81....	First..........	133	9.4	.106	80.8	28.8	3.52	25.3	272	239
82–83....	First	256	9.2	.108	82.6	30.6	4.12	26.5	283	245
52–83....	....	3,817	14.4	.669	....	17.3	77	16.6	251	240

The usual method for determining the threshold of development is to use the reciprocals of the periods and the average mean daily temperatures as the coördinates and plot the one against the other, then draw a line which best fits the points, and the point where it crosses the temperature axis is the threshold of development. This method serves quite well when the temperatures are constant, but the more widely the temperature varies during the daily variations the less accurate are the results. The accompanying figure is really four figures placed on the same sheet, and represents the points in the various positions assumed by them at the different stages in the solution of the problem.

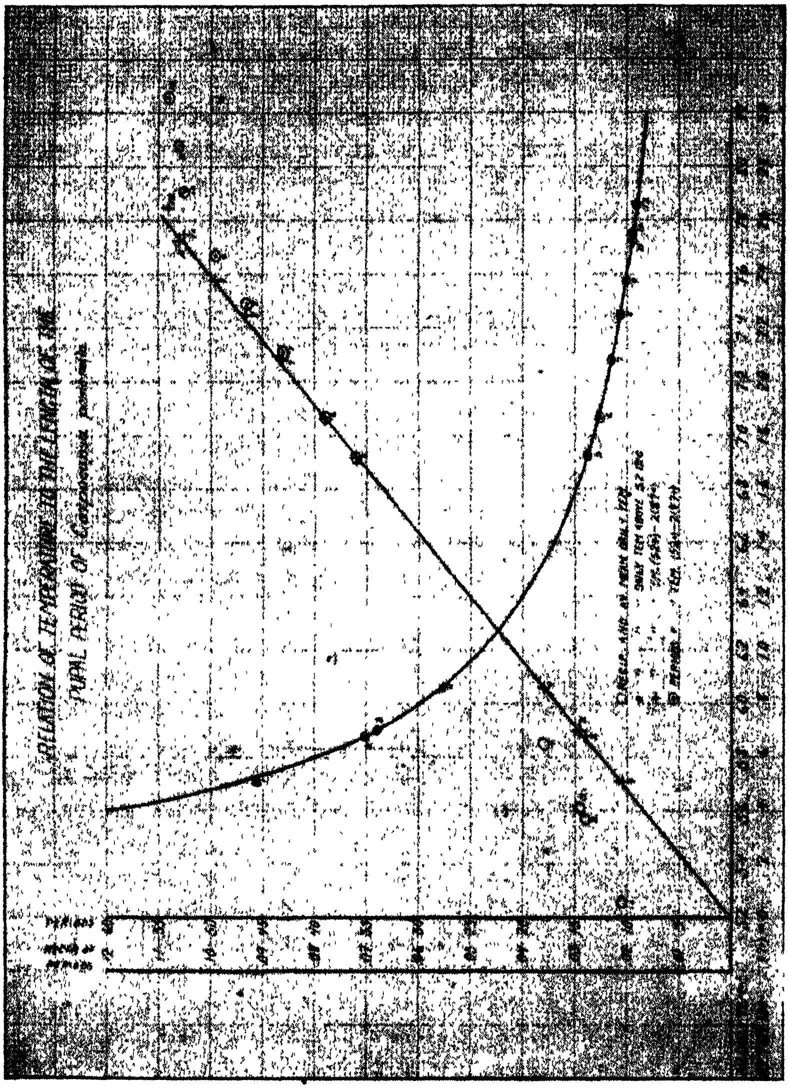
The circles represent the position of points resulting from plotting the reciprocals of the periods against the average mean daily temperatures. These points do not fall in a straight line, but at the lower end they are too far to the left, because the average mean daily temperatures are the averages of temperature readings below the threshold of development (ineffective temperatures) as well as readings above this point, and the points at the upper end are too far to the right, because the average mean daily temperatures here are averages of readings above the degree of the maximum rate of development (retarding temperatures) as well as readings below this point.

A line that would fit these points would be too flat. Now the points that are least affected by these ineffective and these retarding temperatures are those between the average mean daily temperatures of 68 and 72. A line drawn through these two points cuts the temperature axis at 51.92 degrees. This is so nearly 52 degress that, to avoid fractions, 52 was assumed to be the approximate threshold of development.

The average daily degrees above 52 were then computed with results as shown in column 7. The points marked by dots were plotted by using the reciprocals of the periods and the average daily temperatures above 52 degrees. It will be seen that at the lower end of the line the points come into line with the two points used to establish the line, but at the upper end of the figure they are in the same position as the points located by plotting reciprocals against average mean daily temperatures.

It was necessary now to ascertain the degree of the maximum rate of development. The only way to determine this point is by trial.

It was assumed at first that temperatures above the degree of the maximum rate of development were ineffective and did not ac-


RELATION OF TEMPERATURE TO THE LENGTH OF THE
PUPAL PERIOD OF

celerate the rate of development. On this supposition 84, 85, 86, 87, 88 and 89 were taken in turn as the degree of the maximum rate of development and the proper corrections made. This did not bring the points back into line, as the points higher up still stood too far to the right. It was then assumed, after a careful inspection of the data, that temperatures above the degree of the maximum rate of development not only did not accelerate but retarded the rate of development in the same proportion as an equal fall in temperatures below this point would retard it.

On this supposition 84, 85, 86, 87, 88 and 89 degrees were in turn taken as the degree of the maximum rate of development, and corrections made in the location of the points in each case. It was found that 87 degrees gave the best results. Points represented by the crosses were then plotted, using the reciprocals of the periods and the average daily temperatures above 52 degrees, diminished by twice the average daily temperatures above 87 degrees. This brought all the points nearly in line with the two original points used in determining the line, indicating that the second supposition relative to the effects of temperatures above the degree of the maximum rate of development is correct and that 87 degrees is approximately the degree of the maximum rate of development.

The corrections for temperatures above 87 degrees are entered in column 8 and the corrected average effective temperatures (day-degrees) are entered in column 9.

The day-degree is used as the thermal unit and is equivalent to a temperature of one degree lasting for one day. The product of the day-degrees above 52 degrees (column 7) by the periods (column 4) are entered in column 10. It will be noted that they are nearly constant for the lower temperature, but increase as the higher temperatures are reached.

The product of the day-degrees above 52 degrees diminished by twice the day-degrees above 87 degrees (column 9) are recorded in column 11. It will be seen that they are nearly constant for all temperatures.

The average of these products is 240.

The formula is $C = P(T - 2t')$ in which $C =$ constant. $P =$ period in days, $T =$ average day-degrees above 52 degrees and $t =$ average day-degrees above 87 degrees. This formula is the equation of an hyperbola. Plotting the periods expressed in days against the effective day-degrees $(T - 2t')$, we have the points as represented

by the concentric circles. The curve through these points is an hyperbola whose equation is $P(T-2t') = C = 240$.

This constant (240) is the average of 3,817 observations. We may, therefore, conclude that it requires an average accumulation of 240 effective day-degrees to bring the codling moth through the pupa stage. The observed variations from this average in the case of individuals were very great, due in some cases, no doubt, to errors in observation and in part to individual differences, but for the most part to the fact that the day was used as the unit of time. By using the day as the unit of time the actual period might in some cases be nearly a day shorter than the observed period, and in other cases nearly a day longer.

In midsummer the daily accumulation of effective day-degrees was sometimes as high as 27, so that the accumulation of day-degrees for some of the observed periods might be 27 day-degrees greater or less than for the actual period, or the average 240.

The following table shows the range of variations:

Number of individuals.	Day-degrees.
1	166
1	185-194
4	195-204
3	205-214
110	215-224
602	225-234
2238	235-244
653	244-255
170	254-265
18	264-275
7	274-285
7	284-295
2	294-305

Recorded accumulations of less than 205 or more than 275 were probably due to errors in observations; if we add 27 to the former and subtract 27 from the latter, we still have a variation of from 232 to 248 due to individual differences, humidity or other causes. The equation for the pupal period may, therefore, be written as follows:

$$P\ (T-2t') = 240 \pm 8.$$

This paper was prepared merely to illustrate the method followed in determining the time-temperature factors, or the equation for the period. The method is applicable to the investigation of any stage of an insect.

If the threshold of development and the degree of the maximum rate of development should be found to be the same for each of

the stages of a given insect, the constant of the equation for the whole period from the deposition of the egg to the emergence of the adult may be found by adding the constants of the equations of the stages, and, by making suitable allowance for the time which elapses between the emergence of the adult and the deposition of eggs, a formula for the whole life cycle of the insect may be determined.

These equations may be of practical value in several ways.

By computing the normal daily effective day-degrees in any locality, the number of generations of the insect in that locality, and the normal dates on which the first eggs, or larvæ, may be expected to appear in that place can be ascertained. If any part of the season should be abnormally cold or warm, the amount of retardation or acceleration in development can be computed by keeping a daily record of the effective day-degrees and comparing them with the normal temperatures. In this way we should be able to ascertain when the injurious phase of any insect pest is approaching long enough beforehand to enable us to take whatever precautionary measures are necessary to avoid injury.

In the case of the codling moth, the dates when the larvæ of each generation may be expected to enter the fruit can be determined long enough beforehand to enable the owners to apply the spray at the right time.

How well this method of forecasting insect injuries will work out in practice only time can tell; however, the plan seems to be a feasible one, and one worth investigating.

THE

KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV, No. 11—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 11.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 11.

Some Biological Notes on Philippine Zoölogy.

BY FRANCIS X. WILLIAMS.

THESE few notes are very fragmentary and not all the data are derived from original investigations. They are set forth, however, in hopes that the reader who has not visited the tropics will find something of interest in them. The writer has spent the total of about two years in the Philippines, chiefly at Los Baños, Luzon, and thus has become acquainted with some features of the natural history of this very rich locality.

ANTS.

It is quite evident that the ant is well off in the tropics. An abundance and variety of food, as well as great diversity of conditions, suit the needs of the multitude of its species and make this family of insects a most conspicuous one. Many ants are harmless, or even beneficial, while others are a great pest in the house or in the field.

The well-known, red tree ant, *Œcophylla smaragdina* Fab. (Camponotinæ) is occasionally a decided nuisance along the outskirts of the forest and in portions of cultivated districts near by. This aggressive insect has at least one thing in its favor, for while it bites viciously, it cannot sting. It is a tolerably large, long-legged creature that lives on trees and bushes, where it constructs an ample ball-like nest of leaves spun together with the silk of its larvæ, which are carried about by the workers as this silk is needed. *Œcophylla* frequently swarms on tree trunks and foliage, and so a passer-by may unknowingly gather some up; of these a few will eventually and unnoticed gain a point of vantage on his person, as the back of the neck, and there bestow a vicious and startling nip. Certain homopterous bugs that produce honeydew are attractive to

these ants and protected by them, but other insects that are not thus useful, and that can put up a struggle, are subjected to a gruelling treatment before they succumb. And so it is not unusual to come upon some unfortunate bee or beetle stretched out, more or less tautly, as fire fighters hold a life net, by a circle of these ants, each steadily and relentlessly pulling on a leg or other portion of the victim's anatomy.

The large genus *Polyrhachis* is best represented in the forest. These ants also use silk in nest building, but usually mix in with it small debris of various sorts. A large number of the species have a glossy appearance. Some make a sort of ball-like nest among the leaves of bushes; others will cover over a hollow, as the cut end of a bamboo, with a sheet of debris. Others still, often large species, will build on the trunks of trees, where the nests are placed in crevices or among the exposed roots. In these, the tubular aperture to the nest, with its soft, flexible rim, was found to bear fine, more or less inward-projecting hairs. Other nests may be high up upon tree trunks, and measure as much as a foot and a half long by about half as wide. They consist of a bulging sheet or curtain of silk, etc., secured along its margin to the tree trunk. I remember such a nest on the underhanging side of a tree with pale bark, and which color it somewhat resembled. As the name implies, these insects are armed, more or less, and sometimes in quite a fantastic manner, with spines or hooks, which, as they will often stick into one's fingers, may make capture rather awkward. *Polyrhachis* is only a fair nipper, but the offensives and defensives are effected mainly by raising itself upon its legs, curving the abdomen under and forward, and the squirting out a fluid.

The myrmicine ants of the genera *Solenopsis* and *Phidologeton* can be very annoying insects, particularly during the wet season. *Solenopsis geminata* Fab., also known as the fire ant because of its smarting sting, is widely distributed in the tropics of both hemispheres. It is a rather small, yellowish-brown species that often swarm in the lowlands. In *Phidologeton* we have a genus of few species that appear more shade-loving than *Solenopsis* and which also live in very large colonies. The great majority of specimens in a nest are of small size, but the queens and the largest neuters or soldiers are comparatively immense. The ants are great travelers, and their irregular columns, often encountered crossing a path, are sparsely though conspicuously sprinkled with the great polished soldiers. These big, lumbering creatures are not to be feared; it is

the army of little workers that must be respected, for they are of a vindictive nature and lose no opportunity of using their sharp mandibles. *Phidologeton* will occasionally invade houses here, and once in a while some of the occupants are driven out of bed. There is a record of a village in India having to shift because of these troublesome ants ("Fauna, British India, Hymenoptera," II, p. 161, 1903; Bingham quotes Rothney). The genus belongs to the Indo-Malayan region, and, like *Solenopsis geminata,* is largely granivorous. It is to be noted, then, that meat eaters are not always the fiercest. *Pogonomyrmex,* the aggressive and efficient stinger among ants in some of the more arid portions of the United States, is also a granivorous insect.

While the ponerine ants are comparatively few and inconspicuous in the United States, this primitive subfamily is very well represented here and contains some of the largest and commonest ants. Notwithstanding their superior size, in many cases they cannot cope against quite small, well-armed ants. This was noted in the genus *Diacamma,* and upon an invasion by such small ants, the former will grab bag and baggage, and, hurrying out of their nest, commonly situated in a tree trunk, await the departure of the marauders. Besides, as is generally the case with the Ponerinæ, their colonies are small, and sting and jaws do not count for much against a superior number of small ants, especially when many of the latter discharge a very disconcerting fluid in their battles.

The Dorylinæ include the famous driver or legionary ants of the American and African tropics, that in their foraging marches clear the path of insects and other creatures. In the Philippines I have observed no such formidable ants, and the only representatives of this subfamily familiar to me are rather small, wiry black species of the genus *Ænictus,* that travel in narrow columns. The workers, although blind, march with order and great activity. They appear to prey on other ants.

While still on the subject of ants, it would be well to consider briefly some habits of the rather large muscid flies, *Bengalia* sp. These are somber-colored insects of alert habits that hang around the passing columns of certain ants, very often those of *Phidologeton.* It is quite usual to see one or more of these flies perched right near the moving ants, and once in a while to approach a burdened ant, seize and snatch away its load and to consume it at a safe distance. *Bengalia,* then, feeds upon the early stages of ants and whatever palatable food the ants may carry. Thus, a *Phidologeton*

army returning, laden mostly with soft, white ants or termites, was patronized by one of these flies. The burdens being large, however, necessitated several ant-carriers apiece, and thus made it rather difficult for *Bengalia* to operate.

Among the numerous arthropods that resemble ants are various spiders. That some of these are more or less associated with the ants they resemble is beyond doubt, but the whole subject, I believe, is still in a rather speculative stage. There are spiders that resemble *Œcophylla;* many, *Polyrhachis;* some, *Diacamma* and others. This resemblance is often excellent, though one will learn quickly to differentiate ant and spider. The latter usually has much the better vision of the two, and so if disturbed will wheel about sharply, very unlike an ant. Spiders have four pairs of legs, and these ant-resembling species, in what suggests to us an endeavor to mimic antennæ, will wave the first pair of legs, also unlike an ant. While these spiders are slender, and, like ants, properly constricted, the large chelæ do not much resemble the jaws of ants. They have somewhat the habits of attid spiders.

SOME BUTTERFLIES.

Butterflies are not all children of the light. The tropics possess a number of species that are addicted to a night life, or that at least avoid the sunlight—mainly somber-colored insects that belong to the families Hesperiidæ (or skippers) and Satyridæ—and elsewhere they may be seen at sunset, or perhaps earlier on dark days, and sometimes also before sunrise, flying about, feeding or laying their eggs. I have found them coming to light but rarely, and it seems probable that they are not so active when the night is far advanced.

The largest of these crepuscular species that I have observed is the coconut nymphalid, *Amathusia phidippus* Johanssen, a graceful brownish insect with a wing expanse of about four inches. The larva eats the leaves of the banana, the cocoanut, and probably of other palms.

The banana leaf roller, *Erionota thrax* Linné, is quite a large skipper butterfly, whose larva makes a retreat of a strip of banana leaf, which it cuts away from the edge and more or less parallel to the midrib and rolls up as a wide ribbon. When it has outgrown or consumed most of this roll, it constructs another and larger one and pupates in the last one made. The larva is covered with a mealy white substance.

A skipper even larger than the banana leaf roller, and also prob-

ably crepuscular, lays its eggs on the rattan (*Calamus*), a species of thorny and climbing palm. The larva is covered with a flocculent white material. It pupates in a neat retreat of rolled-up leaflets. The sensitive pupa even when gently disturbed, will so move as to produce what is at first a rather startling, whirring or scraping noise. Other large skippers feed also on palms, on plants of the ginger family, and on Araliaceæ.

The largest as well as one of the handsomest of the day butterflies is the bird-wing butterfly, *Ornithoptera nephereus* G. R. Gray, with colors chiefly velvety black and brassy yellow, and a wing expanse of about six or six and a half inches. Though a fine insect, it is by no means the largest nor the handsomest of the genus. It is found in the lowlands to some distance up in the forest. The larva feeds on a species of *Aristolochia* or "Dutchman's pipe vine," which it shares with *Papilio antiphus* Fabricius, a much smaller, mostly black butterfly. The larvæ of these two species, as well as that of *Papilio philenor* Linn of North America, resemble one another somewhat in that they have fleshy processes on the body. The pupæ also are swollen at the sides much more than any other pupæ of *Papilio* that I know of.

The genus *Ornithoptera* is sometimes considered a subgenus of *Papilio,* and ranges south, well into Australia.

FIREFLIES.

We have fireflies with us practically throughout the year. This is in striking contrast to the comparatively brief season of the adult beetles in the United States. But there is this much to be said in favor of the latter. I have seen no Luzon island lampyrid that equals in brilliancy the light that is emitted by *Photuris pennsylvanica* of the Eastern United States.

There are quite a number of species found in this portion of the Philippines. Some have a weak luminosity, while others are quite brilliant, and it is a common thing to see a whole bush or crown of a tree sparkling like an old-fashioned Christmas tree, with hundreds of these insects. Such trees, especially when isolated, are visible from quite a distance.

While the larvæ of fireflies, being luminous themselves, are not difficult to find, I do not believe that many Philippine species have yet been associated with the adults. I have found some, as related by Fabre in Europe, devouring snails within their shells, the victim having been overcome on some bush or on the ground. In the

United States the larva of the genus *Phengodes* is known to feed upon myriapods. Here at Los Baños is a related insect with a similar prey. I have kept some of the larvæ in captivity and fed them living myriapods of at least two species, and have several times seen the beetle larva overcome its large prey. It would grasp the myriapod by an antenna, and while its victim might struggle violently, the sharp mandibles of the aggressor seemed eventually to pierce the antenna and to discharge through it a quieting fluid. At any rate, the prey is rendered helpless without further biting, and its interior hollowed out by the voracious larva.

OTHER THAN INSECTS.

One concerned chiefly with the study of insects cannot, however, fail to secure an interest in other invertebrates, as well as vertebrates, that come to his notice.

The land leech is one invertebrate with which those who explore the mountain woods in damp weather soon become acquainted. If the leech feeds solely on blood, it must possess great powers of fasting. It is a tough, wormlike creature, often adorned with brilliant stripes, and that measures in the neighborhood of an inch in length. It is furnished with an anterior and posterior sucker, by the use of which it travels much after the fashion of certain moth caterpillars known as inch worms or loopers. It is very alert to a footfall, and from some little distance, conscious of the presence of man or beast. Perched on an herb or in the middle of a trail, and raised up on its hind sucker, it is quick to grasp a passing leg with the anterior sucker and climb on. Other leeches in the vicinity may wave their head end, or move along in haste in search of this prospective meal. Once aboard, the hungry leech seeks to make a puncture in the skin. This may be a difficult matter in the case of a human being whose legs are well wrapped in cloth puttees, or else very easy if leather leggings or none are concerned. Firmly affixed, it becomes so filled with blood as to present a very rotund and inactive appearance, and eventually to drop off. The leech, however, is on the whole much more disgusting than painful, as in fact one may not become aware of its work until it has dropped off, full fed. Like the hobo, the leech does not relish soap, and the barefooted native keeps this in mind and secures partial protection by rubbing it on.

Most people look upon the crab as a denizen of the sea, or at least as an inhabitant near the seashore. However, rather small-sized crabs inhabit fresh-water streams near Los Baños, and I have found

them from two to three miles up such watercourses, the latter flowing into a large lake. One of these crustaceans was dug out of a decayed log along a stream at an altitude of perhaps 700 feet on Mount Maquiling.

Tailless amphibians are numerous on Mount Maquiling, and may occur at a considerable distance from permanent water. A quite large species with much of the general appearance of our tree toads patronizes suitable vegetation, and is not averse, on occasions, to visiting houses. Along the streams are large frogs which probably do not equal our famous bullfrog (*Rana catesbiana*) in average size. They are very neat and fearless divers, and take surprising headers, from some well-chosen point, into the pool, many feet below.

Of lizards, skinks are the most noticeable, as they scurry away at your approach and rustle among the leaves. They are fond of sunning themselves along the sides of paths. Some are over a foot long and rather stoutly made. Very small lizards, presumably young skinks, are often plentiful in the forest. A species of *Draco,* or flying lizard, seems to occur chiefly in the lower portions of the forest. Its parachuting power is secured through the extension of its ribs beyond the body proper, so that a wide sailing surface can be produced. This expanded area is somewhat gaudily colored and visible only when the lizard is in "flight," for when at rest the ribs are pressed alongside the body. Then the skinny and harmless little creature shows nothing of its aëronautic propensities. It is arboreal, and sails from one tree to another in an easy descent, making a graceful upsweeping landing. Despite such powers, these lizards do not appear to wander far, as I have seen them patronizing the same tree for months.

Coming to grosser lizards, the monitor lizard (*Varanus salvator* Laur.) is noticeable for its large size and noisy haste when alarmed. It reaches a length of several feet and is pretty well at home in the water, on land or up in a tree. It no doubt consumes a variety of food and has quite a reputation as a chicken thief.

While snakes are common here, they are not to be found on every occasion, and large ones are somewhat of a rarity. Pythons (*Python reticulatus* Schneid.) occur in this region, and several years ago two soldiers shot a specimen about twenty-four feet long. Such examples are few and far between.

Of birds, the red jungle fowl (*Gallus gallus* Linnæus) much like

some of our smaller domesticated chickens, may be heard crowing in the forest far from human habitation. However, they not infrequently associate with the tame fowl.

There are some very gaudy kingfishers in the woods. While some favor streams, others may be found in the dense woods and must be largely insectivorous.

There are no large carnivorous animals here. Mount Maquiling has its full share of wild pigs, deer and monkeys. Any of these may during the night come quite close to human habitations and inflict minor damages to crops. Monkeys travel in companies among the trees and feed upon the abundant fruits. They are not especially noisy and their tails do not appear at all prehensile. A powerful but rare eagle, *Pithecophaga jefferyi* Grant, is known to prey upon monkeys in the Philippines.

THE

KANSAS UNIVERSITY

SCIENCE BULLETIN

VOL. XIV, No. 12—OCTOBER, 1922.

(Whole Series, Vol XXIV, No. 12)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 12.

Notes on Nesting of *Polistes* (Hymenoptera, Vespidæ).[1]

BY DWIGHT ISELY,
Department of Entomology, University of Arkansas.[2]

BY FAR the most abundant paper wasp in northwest Arkansas is *Polistes metricus* Say.[3] Its nests can be found almost anywhere attached to trees or shrubbery or under the eaves of buildings. They are often quite numerous. As, for instance, along a stream for a distance of about three hundred yards the writer counted twenty-two nests early in May, 1921. In a small block of apple trees, somewhat less than an acre in extent, seven nests of this species were noted in October of the same year. About premises of the insectary of the United States Bureau of Entomology at Bentonville, Ark., the same season, five nests were built.

The following notes relate largely to one of these nests which was built just outside of the screen, and under a shutter, of the insectary, conveniently situated for observation from within, where complete immunity from stings could be enjoyed. The history of the nest is as follows:

The stem of the nest was begun May 18 by a female wasp. On May 20 three cells were started, and three more were begun the next day. As soon as the base of each of these cells was built, an egg was deposited in it; thus six eggs were deposited in two days. From now on cells were added less frequently, but considerable time was given to enlarging those already started. On May 23 two more cells were started, and the walls of one of the first cells were 8 mm. long. Two more cells were added May 28. An egg was deposited in one of these, but not in the other until May 30. This marks the end of the

1. Published with permission of the Secretary of Agriculture.
2. Formerly with U. S. Bureau of Entomology: Deciduous Fruit Insect Investigation.
3. Determined by Mr. S. A. Rohwer, U. S. Bureau of Entomology.

first stage in the history of this nest. No more cells were added until near the time of maturity of the offspring.

Hatching began May 30 with the three eggs which had been deposited on May 20. Two eggs deposited on May 21 hatched on May 31 and one on June 1. The incubation period of five eggs was ten days and of one eleven days. Records of incubation were not complete for the other eggs, but they required about the same time.

The wasp larvæ grew rapidly, but at an unequal rate. This was apparently due to the fact that some were favored in feeding. The first grub spun the cap, closing its cell for pupation June 9, and the other cells of the first-hatched larvæ were closed June 1, 13, 15, 17 and 21, and July 9, making the larval period vary from ten to thirty-eight days. In contrast to this extreme variation, the period required for pupation was exactly eighteen days in all instances, the wasps maturing on June 27, July 1, 3, 5, 9 and 27. All were females.

For two days after emergence from its cell the first wasp stayed on the nest. After that it began going to the field, and soon was doing most of the field work; that is, bringing in paper for nest building and partially crushed insects for larval food. Caterpillars were apparently the most frequent prey. The parent wasp stayed at home, received supplies from the worker, and at first did most of the feeding of the larvæ and actual adding to the nest. As the number of offspring increased, there were always several on the nest ready to meet a field worker and unburden it of its supplies. The field workers also often engaged in feeding the grubs.

Shortly before the emergence of her first offspring, on June 21, the parent wasp began three new cells and deposited eggs in them. Three more cells were started on June 27, and from then on building progressed rapidly. By July 10 there was a total of thirty-one cells in the nest, and all of the cells vacated by maturing wasps were renovated and eggs were again placed in them. At the close of the season a total of eighty-two cells had been built.

This nest seemed to be fairly representative for rate of growth and size. Two other nests which were started about the same time were observed occasionally. On July 9 one had three wasps and fourteen cells; the other had six wasps and twenty-four cells. At the end of the season they had seventy-four and 102 cells, respectively. The total number of wasps in any of the colonies was not definitely known.

The first male wasp appeared August 12, and after this for at least three weeks there was a large emergence of drones. The time

of appearance of the first sexually mature females was not noted. The males did not go afield with the regularity of the females, but spent most of their time on the nest, so that they made up the greater proportion of wasps on the nest during the day. These males were apparently waiting on the nest for the emergence of sexually developed females. What was probably a preliminary to mating was observed twice. As a female wasp was emerging from her cell she was pounced on by a male and then by all the males on the nest. This mass of wasps fell in a ball to the ground. When disturbed by the writer, they separated. Mating was not observed. A similar performance was noted at another nest later in the month.

Observations were not made regularly after this time, the writer having left Bentonville, but by the middle of October all males had left the nest. A large number of females still collected there, but all the brood had emerged and all activity had ceased.

Considerable opportunity was offered to observe the workings of the sense of direction, or rather the apparent lack of any such sense. When the colony consisted of only a few individuals all of the wasps apparently depended on local observations for finding their way to their nest. Any change in the insectary shutters was confusing to them. The oldest of the workers, when returning from the field, was observed to alight on the shutter about a foot below and two feet to the north of the nest. She would run on a horizontal line below the nest and continue until she was about six inches past it, when she would turn at a sharp angle and go directly to the nest. This path was always followed unless the shutter was tampered with, when the wasp could scarcely find the nest at all. None of the other wasps followed this same path, but each apparently had its own system.

The overwintering queens of *Polistes* are sometimes gregarious, a number of them starting a colony together in the spring. I have never observed them working together in building an absolutely new nest, but on several occasions I have seen a small number—never more than seven—of overwintering queens renovate a large nest left from the season before and start a colony together. This probably accounts for the very large nests of several hundred cells that frequently are found. These exceedingly numerous colonies were much more pugnacious than the small colonies. In fact, colonies of but a few wasps are inclined to be shy rather than pugnacious.

THE

KANSAS UNIVERSITY SCIENCE BULLETIN

Vol. XIV, No. 13—October, 1922.

(Whole Series, Vol. XXIV, No. 13.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office at Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 13.

Five New Species Belonging to the Genus *Harmolita* Motschulsky.

(*Isosoma* Walker et Auct.)

BY W. J. PHILLIPS AND F. W. POOS,
United States Bureau of Entomology, Charlottesville, Va.

THREE of the five species described in this paper (viz., *swezeyi*, *panici* and *phalaridis*) would fall within the genus *Harmolita* as restricted by Phillips and Emery.[2] Grahan[3] has more recently redefined the genus, however, and all five of the new species plainly fall within the limits as he has defined them.

At the time this genus was revised by Phillips and Emery, the senior author had seen only a few specimens of *H. cinnæ* (n. sp. described herewith), and since the species differed somewhat from the usual type of *Harmolita*, he did not consider it advisable to broaden the scope of the genus to include this species. Since that time several similar species have come under observation and they seem to be more closely related to *Harmolita* than to *Eurytoma* from a biological standpoint, as well as from the standpoint of external characters and the character of the ovipositor. The writers fully agree with Gahan that it is more advisable to include these species in the genus *Harmolita* than to erect a new genus for their reception.

The principal characters assigned to the genus by Gahan are as follows: Abdomen of female elongate, conical or subfusiform, with segments more or less subequal, the fourth segment (when propodeum is considered a thoracic segment) never greatly enlarged as in *Eurytoma*. Occiput slightly concave and immargined. Antennæ inserted at or above middle of face; flagellum weakly clavate;

1. Order Hymenoptera, family Eurytomidæ.
2. U. S. Nat. Mus., vol. 55, pp. 443-471, plates 39-48.
3. Proc. U. S. Nat. Mus., vol 61, 1922, art. 24, p. 7.

funicle usually five-jointed and club three-jointed, though in some cases funicle is six-jointed and club two-jointed. Propodeum not or scarcely longer than scutellum, not sharply declivous, usually rugosely sculptured; with a more or less distinct median, longitudinal depression. Sculpturing of head and dorsum of thorax either reticulate and shining, rugulose punctate without umbilicate punctures or rugulose with a few more or less indefinite umbilicate punctures.

Prof. C. R. Crosby, of Cornell University, kindly placed his specimens and notes on *H. phalaridis* at the disposal of the writers. Professor Crosby found that this species has two generations a year, each generation confining itself to *Phalaris arundinacea*. The remaining species were reared from dried grasses collected in the field. No further observations on their biology have thus far been made.

Acknowledgment is made to Mr. A. B. Gahan of the United States National Museum for his kindly criticism of the manuscript.

Harmolita swezeyi, n. sp.

(Pl. XXXVI, figs. 2 and 5; pl. XXXVII, fig 7)

Female. Length, 2.90 mm. Prescutum reticulately lineolate and without broad, shallow impressions or umbilicate punctures. Pronotal spots large, occupying about one-half of the anterior margin of prothorax, spots dull yellowish. Sometimes entire thorax and propodeum brownish. Propodeum without a distinct margined, median, longitudinal groove, though there is usually a distince median longitudinal depression. Propodeum rugulose anteriorly and usually granulose in the remaining portion Spiracular carinæ usually distinct but weak. Abdomen equal to or slightly longer than head and thorax combined; conically pointed; second segment equals one-fourth length of abdomen; remaining segments subequal, though five is longest and three shortest. Legs in black specimens are black except at knees and tarsi, which are luteous; in brownish specimens the legs approach the color of the thorax, knees and tarsi lighter.

Antennæ: Funicle five-jointed; first funicle plus ring joints longer than pedical; all of funicle joints usually distinctly longer than broad; middle joint of club apparently quadrate; scape and pedical yellowish.

Species medium to small. Median line of face below insertion of antennæ without markings.

Males. Unknown.

This species will run to the couplet separating *agrostidis* and *websteri* in the Phillips and Emery table of species, but may be readily distinguished from either species by the yellowish scape and the longitudinal depression in the propodeum.

Type locality. Honolulu, Hawaii.

Type. Cat. No. 25,471, U. S. N. M.

Described from thirteen females reared from stems of Bermuda grass (*Cynodon dactylon*), in Honolulu, Hawaii, by Mr. O. H. Swezey.

Harmolita panici, n. sp.

(Pl. XXXVI, figs. 7 and 8; pl. XXXVII, figs. 6 and 8)

Female. Length, 3 mm. Prescutum rugulose; pronotal spots small, occupying one-half or less of the anterior dorsal margin of the prothorax; spots dull. Propodeum with or without a distinct continuous, median, longitudinal groove, though there is a distinct indication of a groove anteriorly; if groove is continuous it is faint and very shallow, and not very clearly margined; rugulose within and laterad of groove. Abdomen rather slender; longer than head and thorax combined; second segment comprising one-fourth to one-fifth length of abdomen exclusive of 1; 3 shortest; 4, 5 and 6 approximately the same length. Legs black except tarsi, knees and the lower face of the front femora, which are luteous.

Antennæ: Funicle five-jointed; first segment plus ring joint slightly longer than pedicel; first and second segment about equal in length; 3, 4 and 5 about equal in length, but each shorter than either 1 or 2; all segments longer than broad. Antennæ black; median line of face below insertion of antennæ without markings.

Species small to medium

Male. Length, 2.51 mm. Prescutum as in female. Pronotal spots minute, scarcely visible from above. Propodeum without a distinct median groove; rugulose. Petiole granulose, somewhat shorter than hind coxæ. Legs colored as in female except that front femora are darker.

Antennæ: Scape almost same width throughout, as seen in lateral profile, with no distinct shoulder near distal extremity. First, second and third flagellar joints with two to three annulations at distal extremity; bristles numerous and short, scarcely half the length of the segments.

The individuals of this species without the propodial groove run to couplet 14 in the Phillips and Emery table of species, but can be easily separated from *hordei* by having the legs not red, and from *tritici* by being a smaller species and the sculpturing being much smoother. The individuals that have the propodial groove run to couplet 18, in which *vaginicola* and *secalis* are separated. Both of these species are longer and more coarsely sculptured; *vaginicola* has yellowish antennal scapes and the propodeum of *secalis* is granulose, which will easily separate them from *panici*.

Type locality. Charlottesville, Va.

Type. Cat. No. 25,472, U. S. N. M.

Described from three females and one male reared from stems of *Panicum clandestinum* at Charlottesville by the junior author.

Harmolita phalaridis, n. sp.

(Pl. XXXVI, figs. 6 and 9; pl. XXXVII, figs. 1 and 2.)

Female. Length, 3.70 mm. Prescutum reticulately lineolate with numerous broad, shallow impressions; very few such impressions on pronotum, but scutellum is quite thickly pitted. Pronotal spots bright and large, occupying about two-thirds anterior dorsal margin of prothorax. Propodeum with a distinct, continuous, median, longitudinal groove, which is usually margined; usually deep throughout, though often shallow posteriorly; numerous cross rugæ within groove, but no indication of central carina; very rugulose laterad of groove; spiracular carinæ prominent and spiracular area usually well de-

fined. Abdomen same length as head and thorax combined; segments 3 and 5 about of equal length; 4, 6 and 7 about equal in length and each usually longer than either 3 or 5. Legs: All knees, tibiæ and tarsi usually reddish brown, femora blackish.

Antennæ: Funicle five-jointed; first funicle joint plus ring joint about twice as long as pedicel; first joint of funicle slender and same size throughout, the distal tip somewhat flaring; all of funicle joints distinctly longer than broad; club joints also longer than broad; antennæ black and very slender.

Species medium in size.

Male. Length 2.60 mm. Prescutum as in female, but there are few thoracic punctures; pronotal spots large and bright. Propodeum with or without a groove; groove when present is often rather poorly defined; propodeum usually very rugose, though it may sometimes be granulose; spiracular area usually well defined. Petiole usually about twice as long as broad, granulose and extends beyond the tip of the coxæ. Legs: All knees and tarsi testaceous; front tibiæ usually reddish brown.

Antennæ: Flagellum with peticel longer than head and thorax combined; hairs on first flagellar joint approximately same length as those on last joint; last joint bears a slender tubercle at end about twice as long as broad. Scape, exclusive of base, a little over twice as long as broad, broadest about center, as seen in lateral profile; scape as seen in lateral profile nearly twice as broad as first flagellar joint. There are four or more annulations at each articulation of the flagellum.

This species runs to *dactylicola* in the Phillips and Emery table of species, but the females may be separated by the following characters: *H. phalaridis* has more densely pitted scutellum; propodeum more rugulose; groove deeper and same width throughout; spiracular carinæ more prominent; tibiæ usually reddish brown; first funicle joint of antennæ cylindrical, very slender and distal extremity somewhat flaring at tip. All segments of antennæ more slender than in *dactylicola*.

Type locality. Ithaca, N. Y.

Type. Cat. No. 25,473, U. S. N. M.

Described from many males and females reared from stems of *Phalaris arundinacea* collected at Ithaca, N. Y., by Professor Crosby and the junior author, and from specimens reared from stems of *Phalaris* sp. collected at Elk Point, S. Dak., by Mr. C. N. Ainslie of the U. S. Bureau of Entomology.

Harmolita cinnæ, n. sp.

(Pl. XXXVI, figs. 1 and 3; pl. XXXVII, figs. 3 and 4.)

Female. Length, 3.80 mm. The whole thorax somewhat rugulose and more or less distinctly umbilicately punctured, the punctures shallow and usually not well defined; prescutum sometimes not umbilicately punctured in anterior third; pronotal spots small, occupying about one-third anterior dorsal margin of pronotum, visible from above. Propodeum with a deep, margined, continuous, median, longitudinal groove of medium width; groove with numerous cross rugæ and usually with a central longitudinal carina; very rugulose laterad of groove; spiracular area usually well defined, though sometimes the spiracular carinæ are weak. Abdomen equal to or slightly longer than head and thorax combined, and almost as pointed as the average *Harmolita*; seg-

ment 2 occupies between one-third and one-fourth the length of abdomen; segments 3, 4, 5, 6 and 7 approximately equal in length. Legs often variable in color; sometimes the legs are black throughout except the knees, front tibiæ and all tarsi, which are luteous; perhaps more often the basal third to half of front and middle femora and basal two-thirds of hind femora blackish; all tibiæ, knees and tarsi almost reddish brown.

Antennæ: Funicle five-jointed; club three-jointed; first funicle joint plus ring jointly nearly twice as long as pedicel; all segments longer than broad; the first two funicle joints longest, the remaining ones of approximately the same length. Antennæ black. Median line of face below insertion of antennæ slightly elevated; dorsally it appears almost carinate

Species medium to large.

Male. Length, 2.90 mm. Sculpturing of thorax very much the same as in female, except that the umbilicate punctures are not nearly so distinct; pronotal spots very small, often scarcely visible from above. Propodeum variable; there may be a deep, rather broad, margined, median longitudinal groove, very rugulose within and laterad of groove, or the groove may not be continuous and shallow, and it may be granulose within and laterad of the groove. In the latter case the petiole is usually granulose; when the propodeum is very rugulose the petiole is usually somewhat rugulose. Petiole long, slender; the tip of the hind coxæ often extending only to about the middle of petiole. Legs colored as in female.

Antennæ: Longer than head and thorax combined; scape as seen in profile thickened somewhat at center; no distinct club; first segment of flagellum approximately as long as scape; the remaining segments about of equal length; segments excised with about three annulations at the distal extremity of all except distal segment.

Type locality. Youngstown, Ohio.

Type. Cat. No. 25,474, U. S. N. M.

Described from many females and eight males reared from stems of *Cinna arundinaceæ* collected at Youngstown, Ohio, by Mr. W. T. Emery and at Niles, Ohio, by the junior author.

Harmolita phalaricola, n. sp.

(Pl. XXXVI, figs. 4 and 10; pl. XXXVII, fig. 5)

Female. Length, 3.52 mm. Prescutum somewhat rugulose, and the whole thorax bearing numerous but rather indefinite umbilicate punctures. Pronotal spots dull, minute, scarcely visible from above.

Propodeum with a distinct, continuous, deep, medium to narrow longitudinal median groove; groove not distinctly margined throughout; very rugulose within and laterad of groove; spiracular area not clearly defined by spiracular carinæ. Abdomen short and thick, approaching ovate; slightly shorter than head and thorax combined; segment 2 occupying between one-third and one-half dorsal length of abdomen; segments vary in length as is common in *Harmolita*, due to telescoping of segments when the insects die; 3 and 4 often nearly same length; 5, 6, and 7 often about same length, but shorter than either 3 or 4. Legs: Basal half of front and basal two-thirds of middle and hind femora black; remaining portion of legs usually reddish brown.

Antennæ: Funicle apparently six-jointed and club two-jointed; first funicle plus ring joint about twice the length of the pedicel; segments 4, 5 and 6 about quadrate; club joints nearly quadrate also.

Species medium to large.

Males. Unknown.

Type locality. Elk Point, South Dakota.

Type. Cat. No. 25,475, U. S. N. M.

Described from ten females reared from stems of *Phalaris* sp. collected at Elk Point, S. Dak., by C. N. Ainslie of the United States Bureau of Entomology.

PLATE XXXVI.

1. Ovipositor of *H. cinnæ.*
2. Ovipositor of *H. swezeyi.*
3. Propodeum of *H. cinnæ.*
4. Propodeum of *H. phalaricola.*
5. Propodeum of *H. swezeyi.*
6. Propodeum of *H. phalaridia.*
7. Propodeum of *H. panici.*
8. Ovipositor of *H. panici.*
9. Ovipositor of *H. phalaridis.*
10. Ovipositor of *H. phalaricola.*

PLATE XXXVI.

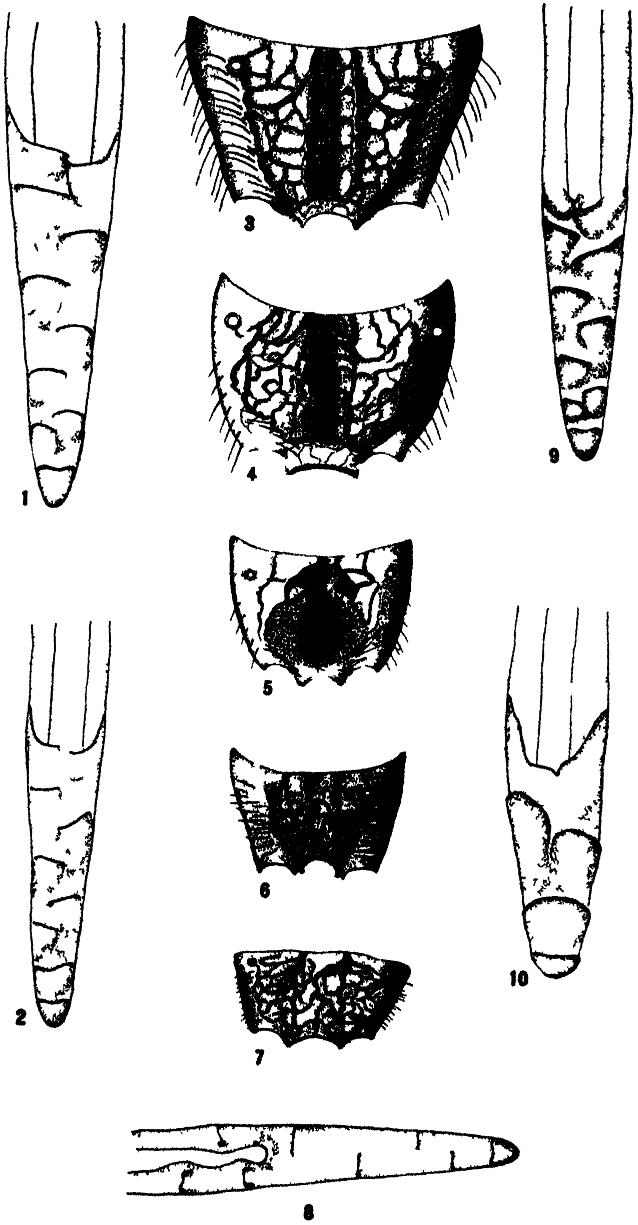
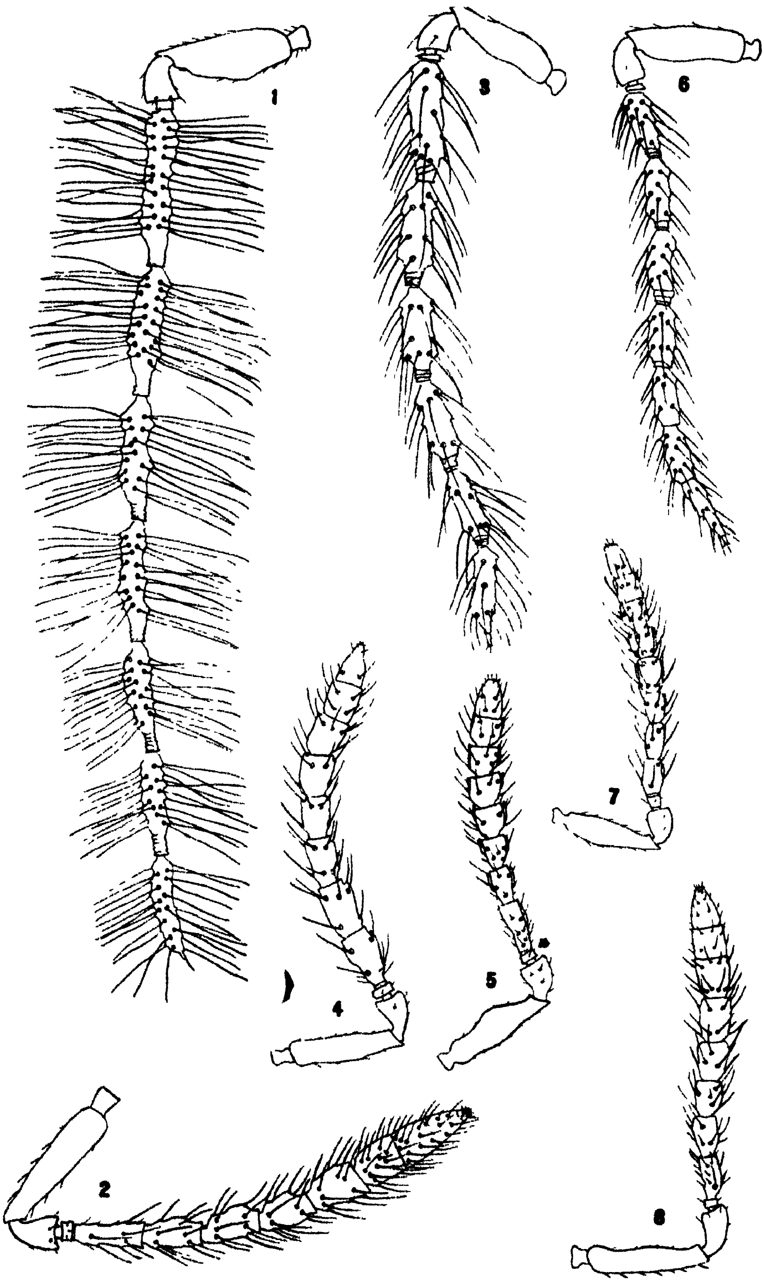


PLATE XXXVII.

1. Antenna of the male of *H. phalaridis*.
2. Antenna of the female of *H. phalaridis*
3. Antenna of the male of *H. cinna*.
4. Antenna of the female of *H. cinnæ*.
5. Antenna of the female of *H. phalaricola*.
6. Antenna of the male of *H. panici*.
7. Antenna of the female of *H. swezeyi*.
8. Antenna of the female of *H. panici*.

PLATE XXXVII.



THE

KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV, NO. 14—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 14.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 14.

The Urinary System of *Phlegethontius sexta* Johan. (Lepidoptera).

BY G. H. VANSELL.

(Contribution from the Zoölogical Laboratory of the University of Kentucky.)

PHLEGETHONTIUS SEXTA Johan., commonly known as the southern tobacco worm, is used in many laboratories for morphological study material. The paper of Alvah Peterson, published in the September number of the "Annals of the Entomological Society of America, 1912," treats the general anatomy of *Protoparce carolina* Linn., but the Malpighian tubules are not shown in his figures as fully as some other parts. If the conditions shown in the figures accompanying this paper differ from those found by Peterson in his work it may throw some light on the proposed synonomy of the species in question.

Malpighian tubules are usually two in number, or in multiples of two, and in most cases they empty directly, or through a bladder, into the intestine. In the larvæ of *Microgaster,* Koulagin found that they open dorsally on the outside of the body on each side of the anus. Those of *Phlegethontius sexta* Johan. empty into the small intestine.

The specimens used for dissection in this work were killed in various ways. Some were dropped into a solution of 50 per cent alcohol, 48 per cent water, and 2 per cent formalin. Immediately after death they were removed and the body wall split to allow the free passage of the preservative to the inside organs. At the time of use these specimens were further hardened by adding a solution of picric acid and chloral hydrate. Others were dropped into Bouin's picroformol mixture, and later run up through alcohols. Various stains

were used upon that material which was imbedded for sectioning. Borax carmine and Delafield's hemotoxylin seemed to give the best results.

The Malpighian tubules of *Phlegethontius sexta* are six in number and of a light yellowish color. Four of these are located largely laterodorsally to the intestinal tract, the other two being ventrally situated. Each tubule is apparently free at the end distad from the bladder. There are two bladders, located one on each side between the ventriculus and the small intestine (fig. 2), and just posterior to the ventriculus they empty separately into the small intestine through short, smooth tubes (fig. 3). From the opposite end of either bladder a tube arises which runs dorsally and branches immediately into two; one of these tubes runs ventrally and forward, the other dorsally, and this one divides into two more as it nears the top of the ventriculus. These six tubes run forward toward the head and turn back posteriorly at about the second abdominal segment, as shown in figures 5 and 6. Posterior to the bladders all these tubes interweave with the adipose tissue until they lose their identity.

On high magnification the tubes present an interesting appearance, in that each one is covered with small nodules. These nodules become more numerous on the tubes the greater the distance from the connection with the bladder, until at the distal ends the nodules are very closely crowded together (figs. 7 and 8). Tracheæ run to the tubes and branch into invisible threads upon the surface of the nodules (fig. 9).

Both the nodules and the tubes are hollow, and an opening from each nodule leads into the tube, making a continuous cavity to all parts (figs. 10, 11 and 12). The exact histological nature of the tubes is very hard to determine on account of their delicate nature. The figures showing these structures are not shown here, for more work is being done upon them and a later paper will appear.

LITERATURE.

BERLESE, ANTONIO. 1909. Gli Insetti loro organizzazione, sviluppo, abitudini e rapporti coll'uomo, pp. 779-788; figs. 971, 972, 975. Societa Editrice Libraria, Milano.

FOLSOM, J. W. 1906. Entomology, with Special Reference to its Biological and Economic Aspects, pp. 123-124. Philadelphia; P. Blakistons & Co.

PETERSON, ALVAH. 1912. Anatomy of the Tomato Larva, *Protoparce carolina*. Annals of the Entomological Society of America, pp. 245-272; pls. XIX-XXI. Columbus, O.

PLATE XXXVIII.

FIG. 1. Dorsal view of the region into which the Malpighian tubules empty. *bl,* bladder; *dd,* Dorsal duct; *ve,* ventriculus; *si,* small intestine.

FIG. 2. Ventral view of the same region. *bl,* bladder; *cd,* common bladder duct; *vd,* ventral duct; *dd,* dorsal duct; *n,* nodule on the Malpighian tubule; *si,* small intestine.

FIGS. 3, 4. Lateral view, showing the left and right sides of the intestine with the bladders and ducts. *ve,* ventriculus; *si,* small intestine; *bl,* bladder; *o,* duct opening into the small intestine.

FIG. 5. Dorsal view of the ventriculus, showing the arrangement of the Malpighian tubules. *2nd,* second abdominal segment; *9th,* ninth abdominal segment; *xx,* region in which the free ends of the Malpighian tubules and the adipose tissue interweave into a dense mass.

FIG. 6. Ventral view of the ventriculus, showing the arrangement of the Malpighian tubules. Labels as in figure 5.

FIG. 7. Malpighian tubules under the microscope, showing the nodules. This piece of the tube occurred just posterior to where a dorsal tube turns caudad. *t,* tubule; *n,* nodule.

FIG. 8. Section from the Malpighian tubule toward the distad end, just anterior to the highly convoluted area. The nodules are quite numerous here and the tube thickened. *t,* tube *n,* nodule.

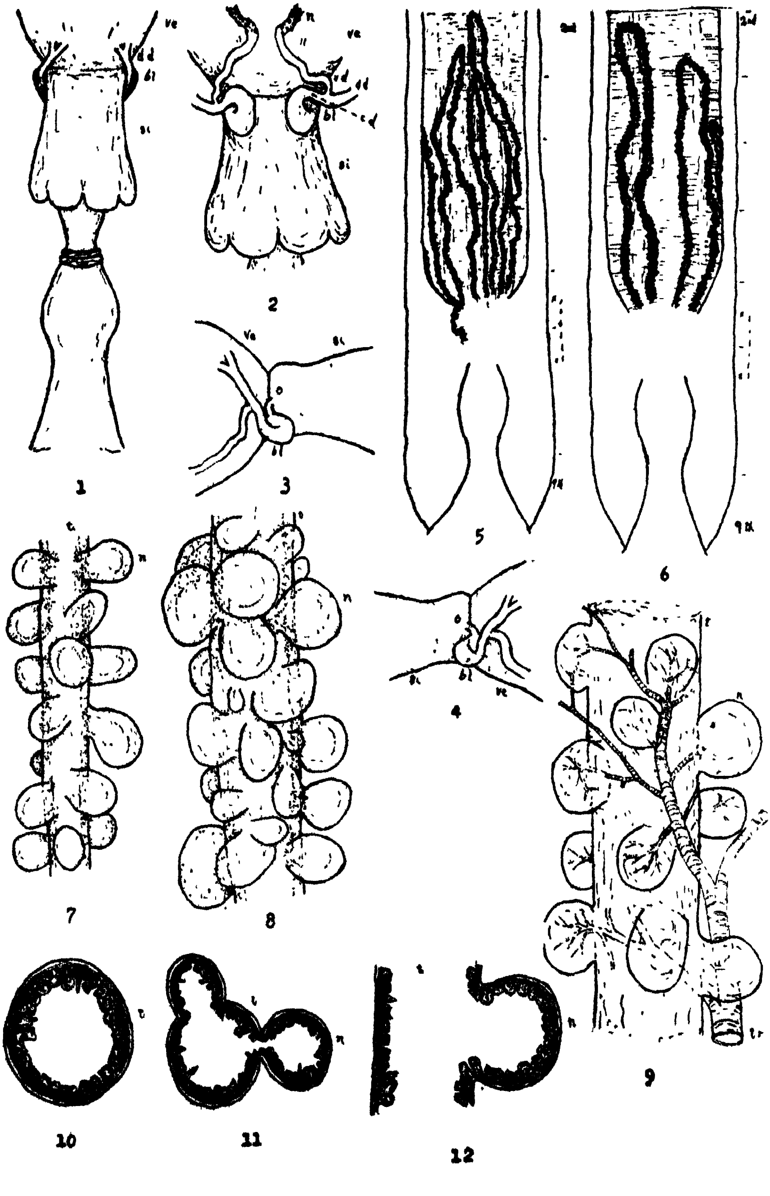
FIG. 9. Highly magnified portion of the tubule, showing the disappearance of the trachea on the nodules. *n,* nodule; *t,* tube; *tr,* trachea.

FIG. 10. Cross section of tubule.

FIG. 11. Cross section of tubule and nodules.

FIG. 12. Longitudinal section of tubule and nodule.

PLATE XXXVIII.



THE

KANSAS UNIVERSITY

SCIENCE BULLETIN

VOL. XIV, No 15—OCTOBER, 1922

(Whole Series Vol XXIV, No 15)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN

Entered at the post office in Lawrence as second-class matter

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [NO. 15.

A Brief Resume of Investigations Made in 1913 on *Trogoderma inclusa* Lec. (a Dermestid).

By ADOLPH H. BEYER.

THE work herewith reported was undertaken at the suggestion of Prof. S. J. Hunter, who had received complaints concerning damage to leather horse collars. The damage consisted in more or less numerous perforations of the leather by some insect, which injury interfered seriously with the marketability of the manufactured goods. It became my task to determine the insect causing the damage, the source of infestation, and the methods of controlling the pest. The investigations were made in 1913, but are reported here for the first time.

NATURE OF THE INJURY TO THE HORSE COLLARS.

The leather of the infested collars has the appearance of being perforated with numerous little round holes about the size of a pinhead. The insects reared from infested collars proved to be dermestid beetles belonging to the above-named species. The insects hatch in the rye straw used in filling the collars, and the larvæ live upon the grain left in the straw. As the larvæ develop to within a month of the adult stage, they approach the outside of the collar and emerge by eating holes through the leather of the collar.

A number of firms engaged in the manufacture of collars have reported damage of this character. One firm in Texas writes: "We wish to state that five or six years ago we had trouble of this kind owing to the fact that we were using rye straw with lots of grain still in the straw, and small worms or insects would bore through the leather into the collar to get at the grain. We had very little loss, as we soon found out the trouble, and therefore quit using straw that had any grain in it at all."

Two or three firms securing straw from a grower near Lawrence, Kan., reported serious trouble. An examination of one factory revealed fifty per cent of the collars infested. Upon examining the floor, walls and window and door casings, the cracks were found to contain many adult beetles, which in all cases were dead. The light and heat of the sun had a marked influence upon the distribution and development of the insects, as the collars near the south windows were more seriously damaged, the injury decreasing gradually as one neared the north side of the building.

SOURCE OF INFESTATION.

Since injury was reported from manufacturers using straw grown near Lawrence, Kan., it appeared possible that the straw might have been infested before it was shipped to the factories. An investigation was made first at the ranch where the rye straw was grown. It was found that the sheaves were stacked up in the barns to conserve the value of the straw for collar-stuffing purposes, and during the winter months a specially made thresher was used in removing the grain from the head of the sheaf without cutting the band. After the rye bundles were threshed they were baled, being compressed and tied with wire ready for shipping to the collar factory. I found no trace of the insect about any part of the sheaves. They were apparently free in every respect from the insect. I also examined the threshed bundles before they were baled, and noticed that there was considerable grain left in the straw, which later afforded food for the development of the insects in the collar. I next examined the threshed rye in the bin, thinking perhaps the insects might be hibernating at this season of the year. I collected several quarts of the rye in a screw-sealed glass jar, to keep out other infestations, and took this, with one of the rye sheaves, to the laboratory.

I placed some of the rye straw taken from the sheaf in a large glass-enclosed cylinder. This was placed in the incubator at ordinary room temperature of 70° F. I recorded the temperature each day and watched for the development of infestations, but noted no development of life for several weeks. At the end of three weeks I found two species of grain weevil and several parasites, which I removed from the jar and placed in separate vials. At the end of the fourth week I removed from the jar five specimens of larvæ, apparently of the same species of Dermestidæ that was the cause of the collar infestation. April 15, the adults emerged from the pupæ cases. I found them to be the same species as those causing the damage to the collars.

EXTENT OF INFESTATION.

As stated before, fifty per cent of the collars in one factory were damaged. I made a careful dissection of both sides of a badly infested collar by removing the leather of the facing of the collar. I have found only the larval stage of the life cycle in the collars so far examined. I made an approximate count of all the larvæ found in this collar, and 900 larvæ was the result. I also counted the number of holes in the same collar leather, to get the per cent of damage done by each insect. The actual number of holes in this collar made by this pest was 424. Approximately 1,324 of the insects infested this collar.

The larvæ varied from 2½ to 5 mm. in length. They were usually found in the heads of the rye, or eating on the scattered grains. The larvæ eat straight across the ends or sides of the grain, something as a mouse gnaws, and not after the fashion of the grain borers. Wherever the tunneling or eating process was found, I also found evidence of molting. I found small larvæ emerged in heads of rye, which is evidence that the eggs had been laid in the heads.

LIFE HISTORY OF THE BEETLE.

In making dissections of the collars which had been incubated at a constant temperature of 70 degrees for several weeks, I found various sizes of larvæ and a number in the pupal state. None was found in the adult state. No eggs were found in the collar dissections.

MATING AND OVIPOSITION.

The beetles I found in all cases mated a day or two after emerging from the pupal skins. The eggs varied in number from ten to fifty. They were placed around indiscriminately on the bottoms of Petri dishes from four to six days after copulation. In a number of cases the female oviposited on the rye placed in the dishes, and the eggs adhered to the rye by means of little filaments projecting from one end of the egg. The young larvæ hatched from eight to twelve days later at ordinary room temperature. The young larvæ, soon after hatching, began to feed on the material at hand. They did not wander unless food was scarce or poor. I reared them entirely upon rye grain. The growth of the larvæ depends to a considerable extent upon temperature and the abundance of food, and it is retarded by weather and scarcity of nourishment. The foregoing factors are not, however, the only causes of slow development. I noted in my experiments that the growth of specimens varies

under identical external conditions. Very often a number of the specimens attain full size, metamorphose, and produce young long before others of the same generation. The majority, however, mature in about five months.

THE EGG.

The eggs are about ½ mm. in length and about ⅙ mm. in width. They are oblong in shape and slightly arched. Not uncommonly they were found adhered together in pairs. One end of the egg usually has hair or threadlike projections. Each egg has a number of ridges running lengthwise and crosswise (see plate XL). The eggs are whitish in color, translucent, and the surface appears rough, and is of delicate skin covering the aqueous interior. It is easily broken. The filaments described at the end of the egg adhere to any object with which they come in contact.

MOLTING.

I found without exception that there is much variation in the rate of molting and the number of larval skins shed by the different individuals of this species. Under normal conditions the larvæ molt twice in about every two weeks. Many peculiarities are worthy of mention. The same specimen often sheds its skin irregularly, sometimes within ten days, and again, under the same conditions, not until a period of three or four weeks has lapsed. The rapidly growing individuals molt more frequently than do those which have about attained their full size. The specimens that are slow in development molt less frequently than do the larvæ which develop at the average rate. The full-grown larvæ previously spoken of, which continue to live for a long time before entering the pupal stage, have a decidedly slow rate of molting. The average rate is about once in every three weeks, and there is a gradual decrease as the specimen grows older.

Thus I have found in all my observations that the number of molts is by no means constant. As previously mentioned, the majority of specimens which complete their life history in about five months, shed their skins from ten to fifteen times, whereas many of the individuals with the prolonged larval history molt as often as twenty times.

The larvæ never eat their own skins, nor the skins of other individuals of this species, even though they may be in the most extreme stage of starvation. This was conclusively proven by placing specimens in a glass vial for the purpose of starving the larvæ, and after

several months of starvation, during which the larvæ had molted several times, the skins were never attacked. This fact was also proven in the collar dissections which I made. In one collar in particular, which had been kept in stock for three years after the infestation was noticed, nearly all of the rye seed had been devoured, and the straw and inner surface of the collar were literally full of molted skins, and a large percentage of the larvæ had escaped from the collar.

Just before molting the specimens become inactive, and a break appears in the larval skin along the median dorsal line. This extends from the head along the thorax and partly down the abdomen (see plate XL). The larva assumes a semicircular position, which permits the extrication of the thorax and the head. The legs are then pulled out of their covering, and the light-colored larva crawls out of the exuvia. Its soft covering soon hardens and becomes chitinous, and within a few hours assumes the natural yellowish-brown color.

PUPATION.

When the larva reaches full growth the pupa begins to form within the last larval skin. This is noticeable by the size, shape and the lack of movement or locomotion. The pupa is slightly shorter, larger in diameter, and apparently makes no movements. Four or five days later the skin splits down the median dorsal line and the light-yellowish pupa is exposed The period of molting lasts from ten to twenty days at ordinary room temperature. When the insects are fully developed they emerge through the large dorsal opening of the pupal skin. Should a specimen be forced out of the larval case when not fully matured, though capable of locomotion, it invariably returns to its former position within the protective larval skin upon coming in contact with it. The pupæ upon emerging are of a whitish color; then comes the darkening of the hair on the thorax and elytra. In three or four days the thorax and elytra take on a reddish color, commencing at the thorax and shading back. The female remains in the pupa case a day or two longer than the male. The average life of the adult is about eighteen days.

FOOD HABITS.

I have found that this species can subsist upon a large variety of substances. In considering the relative value of some of the substances as food for the larvæ, I found that the pest apparently thrives best on cereals. As was formerly stated, the larvæ were, in their natural state, in almost every instance found living on the

grain in the horse collars. Where the grain was most abundant I found the largest percentage of larvæ. In wandering in search of food many holes were made through the straw, upon which they fed in the meantime; and upon coming in contact with the inner surface of the leather, holes about the size of a pinhead were made, through which they emerged, thus injuring the salability and market value of the leather goods. I placed a number of the specimens, soon after they were hatched, on a leather diet, and I found they did not eat at all.

Mr. J. E. Wodsedalek (1912) says with reference to the species *Trogoderma tarsale:*

"A number of the specimens were placed on a feather diet, and although they are now two years old, they have grown but very little. When they were one year old they were very little larger than the newly hatched individuals, and at the end of the second year of life they reached a meager size equal to that which specimens fed on insects ordinarily attain in two weeks. Their development on wool is even slower."

F. H. Chittenden (1897) states:

"One jar of flaxseed from the museum department is infested chiefly by this common museum pest. Many of the larvæ may be seen through the glass, and large patches of their yellowish-brown gnawings and excrement show whene they have been at work. In castor beans a few were present.

"That this species of *Trogoderma* can subsist on a vegetable diet is as positive as it is surprising. No other Coleoptera, to my knowledge, live on oil seeds, and I had nearly arrived at the conclusion that this form of matter was the nearest approach to animal food available, and that these insects could only thrive on such vegetable substances as contain a considerable portion of oleaginous matter. Judge my astonishment when a few weeks after the discovery of the *Trogoderma* living in oil seeds, Doctor Howard brought me a box nearly full of cayenne pepper in which were several *Trogoderma* larvæ. The most careful search failed to show even a fragment of that well-known red pepper pest, *Sitodrepa panicea*, or of any other insect than the Dermestidæ. Subsequently the adult was reared and proved to be *Trogoderma tarsale*.

"To ascertain whether this species would breed on so pungent a substance as cayenne pepper, a few adults were confined with a quantity of this condiment. In due time larvæ appeared, and when examined, August 20, or nearly ten weeks from the time the eggs were deposited, were in vigorous condition, the average individual measuring a tenth of an inch in length, or about half that of the full-grown larvæ. Toward the end of September, while passing through the museum of this department, my attention was attracted by an accumulation of powder and dust about the edges of an exhibit of peanut oil cake, and another of Indian-turnip bulbs. A large number of the larvæ and their cast skins were found under the cakes, also in the flour and meal prepared from peanuts. The Indian-turnip bulbs were very old and dry, and might have been on exhibition twenty years or more.

"When this insect infests a substance of similar color and consistency to flour and meal, only a few larvæ are sufficient, on account of their extraordinary habit of frequently molting, to occasion alarm. In fact, appearances are much worse than the reality. Thus in a small jar of peanut meal in which these larvæ had taken up their abode, about forty larval skins had accumulated when examined September 27, completely covering one-half of the surface of the meal, and giving the impression of a whole colony of insects.

"While the division of entomology was moving into new quarters a bag of Saskatchewan spring wheat, formerly kept in stock for distribution, and described on the label as a hard, amber variety with an exceedingly heavy grain, was unearthed, in which the larvæ of this insect was living, three being present and no other insects except a colony of *Anthrenus* and a single stray *Silvanus*. In fact, this grain is so hard and flinty that weevils would not flourish on it. Soon afterwards I found larvæ in another lot of wheat infested with *Silvanus* and in corn containing *Calandra oryza* and other small beetles. About the same time, Mr. Frank Benton brought me some larvæ found in beehives, where they apparently fed upon propolis in bee glue. There are several recorded instances of *Dermestes lardarius* feeding upon wax, or, more properly speaking, honeycombs, and it is therefore fairly certain that *Trogoderma* has the same habit, although not previously reported in beehives.

"Among the divisional notes I find one recording the receipt of six larvæ of this species in a box of red pepper from a correspondent in Utah, November 22, 1882. These larvæ were kept in a box of red pepper for a year, at which time fifty-four cast skins were noticed. The box was examined January 14, 1887, or over four years from the time of its receipt, when two larvæ and seventy more cast skins were found, but no trace of beetles, although it had been kept closed so that it was impossible for either larvæ or adults to escape. It is very obvious that four larvæ, or the beetles that developed from them, had died in the interim and were devoured by their fellows In any case, the adult was not reared, and no published statement was made of the larvæ having been found living in the condiment.

"The capability of this species breeding in other seeds was demonstrated by the discovery of the larvæ living upon 'kolu,' an edible leguminous seed somewhat resembling a cowpea. The insect had evidently been first attracted by the dead bodies of the original inhabitants of the seeds, the weevil, *Bruchus chinensis*, but had afterward fed upon the seeds, even hollowing them out and leaving only the empty shells. In a similar manner, larvæ were found, together with those of *Attagenus*, in millet and pumpkin seeds that had formerly been inhabited by the polyphagous Indian meal moth, *Plodia interpunctella*.

"In the case of the six larvæ found in the red pepper, it is not likely that four of them metamorphosed, because if they had it is certain they would have been devoured by their fellows. The hard, chitinous covering and the elytra are never completely devoured, even by starving specimens. It is much more probable that they died in the larval stage, and were later devoured by the other two larvæ, or they might have shriveled up and darkened, and were thus easily overlooked. That the two larvæ which were present four years later were two of the original six is highly probable. There are several larvæ in our laboratory which were obtained three years ago, when they were full grown, and they have not changed any since."

BEHAVIOR.

Naturally the larvæ manifest a strong negative reaction to light, and make effort immediately after hatching and when disturbed to seek a shaded or other place of concealment. If placed near a light or window they soon begin to crawl away from the light. It is also quite noticeable when the specimens are placed in a dark room and a strong light is introduced at one end of the glass dish container. This negative phototactic reaction persists throughout life. It is at its highest sensibility to light just before pupation. Thus pupæ are most frequently found in shaded or dark places which afford them a favorable means of protection. The adults, both male and female, retain their negative reaction to light after emerging from their pupal skins. During the period of sexual excitment which follows a day or two later, the insects are still negative, and the females remain decidedly so until their eggs are safely deposited. Several hours or a day after egg-laying, they gradually become indifferent to light, and finally a complete reversal of their former reaction follows. The males also become positively phototactic during the last days of their lives. The larvæ of all stages feign death upon being disturbed. However, when disturbance is continued from a few seconds to a minute at the most, they no longer respond in the same manner. When disturbed the adult insects make themselves very compact by drawing thorax up close to the rest of body. The head is drawn upward and under the thorax, legs and antennæ are folded up, and death is feigned a considerably longer time than in the larval state. The average feint lasts from one to ten minutes

VARIATION IN SIZE.

The adult male insects are smaller, as a general rule, than the female insects, but the small individuals are not always males. There is much variation in the size of the adults. They are from 1.5 mm. to 4 mm. in length, the width also being proportionate. It is difficult to determine the exact cause for this variation in size. Poor nutrition evidently has effect upon the size. However, small individuals appear among the large ones which have lived under very favorable conditions. I noted marked variations in the size of the different larvæ of the same brood within a day or two after hatching. I observed the fact, however, that the small, slowly developing larvæ do not always produce small adults.

ADAPTATION TO FOOD SUPPLY.

An interesting phase of the study of the life history was the extremely long period of time the larvæ can sustain themselves without food. I placed forty larvæ in Petri dishes, ten representative stages, varying from newly hatched to full-grown individuals, without any food whatsoever, for the purpose of determining the period required to produce starvation. I also added a number of Petri dishes, each containing one larva ranging from 1 to 6 mm. in length, and another Petri dish was added, containing a number of a definite size, to determine whether they would eat their skins or not. Measurements were made of all the individuals and records kept. Dishes were examined regularly and measurements made of the representative stages. I also made a record of the cast skins. I found that the larvæ never devour the molted skins of themselves or other specimens. I detected no evidence of cannibalism among the larvæ, even the full-grown starving specimens never attacking the much smaller individuals. Practically all of the larvæ shed their skins shortly after being deprived of food, but the molting process from this on was very much slower. The measurements showed in all cases that the different larvæ decreased in size about one-half their normal length after eight months of life at a temperature of 70 degrees and in ordinary daylight. The newly hatched began to die when about three months old. The larvæ of the middle stage up to the adult stage were all still surviving, and judging from existing circumstances, the survival, especially of the full-grown larvæ, would be considerably over one year. Experiments were carried on with reference to different kinds of diets or foods taken from the collar, as rye seed, rye straw and leather, and in drawing comparisons it was found that they thrived and grew rapidly upon the rye seed, but refused any of the other materials contained in the make-up of the collar.

CONTROL MEASURES.

HEAT.

I first took the trouble to look over the field of available literature relative to the control of this class of insects. I found that the French were the first to know the value of heat, and to devise contrivances for the heating of infested buildings. Experiments were made by Professor Webster to ascertain the amount of heat required to destroy the Angoumois grain moth, which gave the following results:

"A temperature of 140 degrees continued for nine hours literally cooks the larvæ or pupæ, a temperature of 130 degrees for five hours is fatal, as is also 120 degrees for four hours, while 110 for six hours was only partially effective."

It was also found that wheat could be subjected to a temperature of 150 degrees for eight hours without impairing its germinating properties. In the second report of the state entomologist of New York, Prof. J. A. Lintner, speaking of *Tribolium ferrugineum* infesting grain and flour, says:

"A moderate degree of heat, 120 to 130 degrees, continued for a few hours, would in all probability suffice to kill all the eggs, larvæ and pupæ in the material, while a higher temperature, perhaps 150 degrees or more, would be needed for the beetles."

Professor Chittenden, in his paper on "Insects Injurious to Stored Grain," states:

"Prior to the adoption of carbon disulphide as a fumigant, heat was relied upon in the destruction of these insects. A temperature of from 125 degrees to 140 degrees Fahrenheit continued for a few hours is fatal to grain insects, and wheat can be subjected to a temperature of 150 for a short time without destroying its germinating power."

A large number of the experiments of this nature were made relative to the discovery of a method to destroy grain moth, and from the results of these experiments many of the grain insects could probably be destroyed in the same manner, but it would require a higher temperature to destroy the adults than the larvæ or pupæ.

In the first experiment about thirty of the adults and larvæ were placed in a Petri dish which contained rye seed. A thermometer was placed in the vial, with the bulb resting in the middle of the rye, in the Petri dish containing the rye grain and various stages of *Trogoderma inclusa*. The Petri dish was then placed in a dry-heat oven. The bottom and surface of the interior of the oven was covered with asbestos, and the Petri dish was placed upon it, to allow uniform heating. The heat of the oven was raised to 86 degrees Fahrenheit before proceeding with the experiment. No change was noted in the action of the insects. At a temperature of 100 degrees the adults and larvæ began to crawl out of the grain; at a temperature of 110 degrees both larvæ and adults manifested excessive excitement, and were making every effort to escape. They continued to be quite active until the temperature of 115 degrees was reached. At this temperature the adults and larvæ became less active, and at a temperature of 118 degrees the adults were all dead, and also a large number of the larvæ. At a temperature of 119 degrees there was no sign of life. To be sure that I had killed all of

the insects, I raised the temperature to 120 degrees, and then the insects were removed and placed in an incubator and given a chance to recover, but the test showed finally that they were all dead. I repeated the experiment a number of times, and found that as soon as a temperature of from 119 to 120 degrees was recorded it proved fatal to all stages of the insect. It required about thirty minutes to reach this temperature.

In a second series of experiments I continued to use the dry-heat oven, again raising the temperature to 86 degrees. I then took one of the infested horse collars and made a hole in the leather, through which I inserted the bulb of a thermometer into the interior of the stuffing. The collar was then placed in the oven on an asbestos floor to allow equal heating. The temperature was gradually raised to 120 degrees, which took about ten hours. After leaving the collar in the oven for a period of ten hours it was removed and placed in the incubator to allow a chance for the insects to develop again. A day or two following I removed the collar and proceeded to make a thorough dissection of it. I found that the larvæ and adults were all dead. Upon further incubation of the straw stuffing it was found that the eggs had also been destroyed by the maximum temperature, as no more of the insects were hatched.

After demonstrating in the laboratory by experiments that this species of insect could be destroyed at a temperature below that which would be injurious to the leather of the horse collars, steps were taken to test out its results as to the practibility in a seriously infested collar factory overrun with *Trogaderma inclusa*, of the results which were demonstrated in the laboratory.

The means of extermination was left in the hands of the experimenter. The collar warehouse was the only infested floor, and it was located on the sixth floor of the factory. The heating facilities were too inadequate to produce the temperature required to exterminate the infestation; hence, according to instruction, a small room, twelve feet long, eight wide and twelve high, was constructed, and lined on the interior with asbestos. Two large steam-heat radiators were installed, and the collars hung on brackets about the room. One large thermometer was placed in the room and several smaller ones inserted in the collars. The results of this work proved successful.

In this experiment also two thermometers were employed. One was placed in a collar and the other in the chamber. By recording the temperatures at short intervals and plotting them on a chart,

it was evident that the temperature rise in the collar lagged behind that of the chamber. This lag increased as the temperature rose until at 122° F., there was a difference of nearly two hours. Thus the steam was turned into the radiators at 8 a. m. and while the chamber temperature reached 122° F. at about 4 p. m. the collar temperature did not reach this until 6 p. m.

COLD.

A temperature control machine such as is used by this department was used to demonstrate the possibilities of a freezing temperature as a factor in the means of exterminating the pest. A number of the specimens were placed in a vial in the temperature machine. The temperature was reduced to two degrees below zero and held constant for ten hours. The larvæ were apparently dead, but after a short period of incubation the specimens began to be active again. I did not continue the experiments, as I realized the impracticability of this means of extermination.

CARBON DISULPHIDE.

Carbon disulphide is a foul-smelling liquid that volatilizes readily at ordinary temperature, and produces a heavy vapor that is deadly to insects of all kinds when they are confined in a closed space and must breathe it. In reading the data of the various books and bulletins at hand on fumigation, it was found that this gas is especially useful against species infesting stored grains and mills, etc., overrun with Dermestidæ, moth, and so on. There was reason to believe, then, that the insects within the collars could be exterminated if the carbon disulphide could be properly administered to the interior of the collar.

I made a carbon disulphide extermination test of the *Trogoderma inclusa* as they occurred in the horse collars. I prepared a box for inclosing one of the collars by covering it with paper on the inside, and closing it with a tight cover. A small amount of carbon disulphide was injected into the collar by means of a specially devised syringe. The syringe used is modeled after the ordinary type with the exception that a nozzle about four inches in length was devised to reach all parts of the interior of the collar. The instrument is made of steel for durability and strength, as considerable force is required in making the insertion. The nozzle of the syringe was inserted in the collar stuffing, entrance being made between the seams; thus there was no injury to the collar. It was injected at spaces of about four or five inches apart. From six to

eight drams were injected into each collar. The collar was then inclosed in the box and left for twenty-four hours. After making a thorough dissection of the collar, the various larval stages found were all dead, and upon incubation no evidence of recovery was noted in any of the larvæ or adults.

HYDROCYANIC-ACID GAS.

Hydrocyanic-acid gas is a vapor very destructive to all life. The gas is produced by adding potassium cyanide to sulphuric acid. I used these in the following proportions:

Potassium cyanide, 98 per cent pure	1 oz.
Sulphuric acid, specific gravity 1.83	2 oz.
Water	4 oz.

I placed several of the infested collars in a closed chemistry hood. I put an earthen vessel inside, containing water, poured the sulphuric acid slowly in the water, and then added the potassium cyanide, and immediately closed the hood and left the collars exposed to the hydrocyanic acid for two hours, and then opened the hood and let the gas escape. I then took the collars from under the hood and examined the stuffing. There was no trace of life or recovery of the insects in the different stages.

SUMMARY AND CONCLUSION.

The *Trogoderma inclusa* discussed in this paper were found in horse collars that were sent to this department, requesting our advice and assistance in determining the kind and source of infestation and measures to be used in the control of this damaging insect.

With regard to the source of infestation: Upon opening the collars and finding grain in the straw stuffing, and upon examination of the grain in many instances, I noted that it had been eaten upon by the larvæ of this insect, and through the instrumentality of my series of investigations in relation to the life history, I found that they thrived much better upon the grain than any other material found in the make-up of the collars. This gave me a clue as to the source of infestation. After getting some of the stored unthreshed rye, and some of the rye seed which had been stored where it had been raised, I found that a series of incubations produced exactly the same species that was found in the collars.

In considering the matter of infestation and the measures to be used for its control, I suggest that the grain be eliminated as nearly as possible from the straw to be used in the stuffing of the collars, and there will be no liability of serious infestation. However, as I

have experienced personally and through correspondence, many of the people engaged in the manufacture of horse collars are not aware of the value of clean-threshed straw, the seed of which forms an abundant food supply for these insects, and thus follows the dilemma caused by the infestation. Applicable to such cases, I have performed a series of experiments to demonstrate their relative value concerning the means of extermination. Experiments were carried on with heat and cold temperatures and carbon disulphide and hydrocyanic-acid gases, and in conclusion I feel at liberty to state that heat is to be preferred as the best means of control. It insures extermination, and is by far the most economical as well as the safest means of eradicating the infestations.

With reference to the matter of multiplicity and distribution of this species of insect, it was found to be a rare species generally distributed over the the United States and Europe, and is omnivorous in its feeding habits. I found this species to thrive and develop much more rapidly upon seeds and grain foods than any other available material which I had at hand for testing out the food habits.

In making a summary of the variations of the life history of a number of individuals of the same generation, I noted:

1. The adults oviposit from four to six days after emergence.
2. The number of eggs laid by different individuals varied from ten to forty-five.
3. The eggs hatch in from eight to twelve days at ordinary room temperature.
4. The larval life lasts about five months, on the average.
5. The time of pupation is from ten to fourteen days.
6. The adult lives from eight to twenty-five days.

BIBLIOGRAPHY.

F. H. CHITTENDEN. *1893.*—Herbiverous Habits of Certain Dermestids. Bull. 2, N. S. Div. Ent., U. S. Dept. Agr., pp. 36, 37.

1897.—Granivorous and Other Habits of Certain Dermestids. Bull. 8 N. S. Div. Ent. U. S., pp. 14-24, fig. 1.

L. O. HOWARD. Extract from Corres. Bull. 44, Div. Ent. U. S. Dept. Agr., Apr., pp. 90-99.

H. F. JAYNE. *1882.* Revision of the Derm. of the U. S. Proc. Amer. Philos. Soc., vol. XX.

C. V. RILEY. *1883.*—*Trogoderma* as a Museum Pest. Amer. Nat., vol. 17, p. 199.

1883.—Number of Molts and Length of Larval Life as Influenced by Food. Amer. Nat., vol. 17, pp. 347-548.

F. H. SNOW. *1882*.—A New Museum Pest. Psyche, vol. 3, pp. 351, 352.
1894.—Insect Life, vol. VI, p. 226.
1894.—Proceedings of the Columbus Hort. Soc., vol. IX, p. 12; Apr.
1896.—Canadian Entomologist, vol. XXVIII, p. 262; Oct.

W. S. BLATCHLEY. Coleoptera of Indiana, p. 593.
Dec., 1912, Annals of Ento. Soc. of Amer., p. 367.

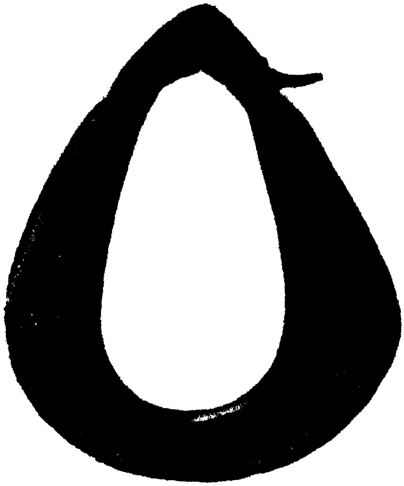
LE CONTE. Synopsis of the Dermestidæ of U. S. Proc. Phil. Acad. Nat. Sc., vol. VIII, 1854, pp. 106-113.

CASEY. Review of the American Dermestidæ. Jour. N. Y. Ento. Soc., VIII, 1900, pp. 138-165.

PLATE XXXIX.

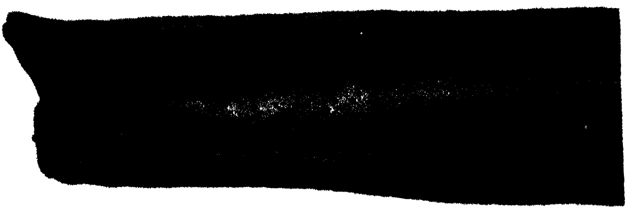
Photographs of leather horse collars damaged by the dermestid *Trogoderma inclusa* Lec. In figures A and B, white-headed pins were inserted to indicate the position of the holes made by emerging beetles. Figure C shows the exit holes made by the beetles.

PLATE XXXIX.



A

B



C

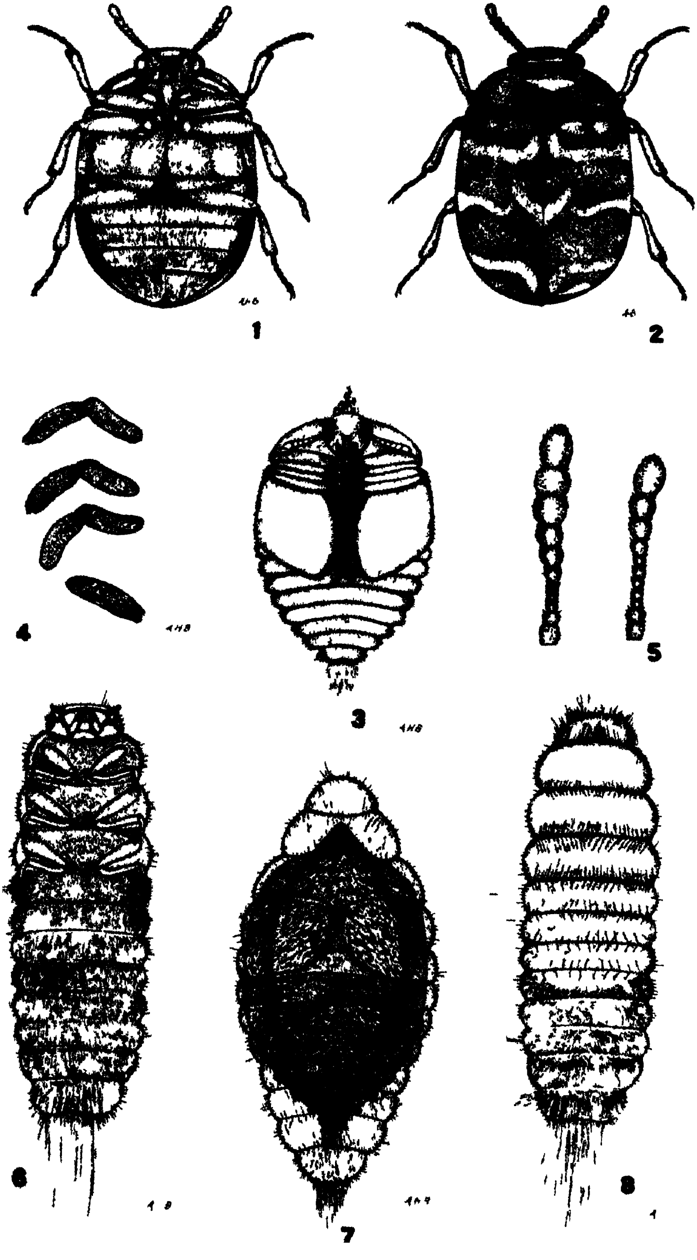
 Photographs by P. A. Readio.

PLATE XL.

Trogoderma inclusa Lec

1. Ventral view of beetle.
2. Dorsal view of beetle.
3. Ventral view of pupa.
4. Eggs.
5. Antennae.
6. Ventral view of larva.
7. Pupa.
8. Dorsal view of larva.

PLATE XL.



THE

KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV, No. 16—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 16.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 16.

The Larva of a Chironomid (*Trissocladius equitans* n. sp.) Which Is Parasitic upon a May-fly Nymph (*Rithrogena* sp.).*

BY P. W. CLAASSEN.

IN AUGUST, 1919, while spending a few weeks in Colorado, the writer was collecting aquatic insects in the Big Thompson river in Estes Park. This river is a typical mountain stream. The water is very cold and rushes along in a swift current over a stony bed. Aquatic insects of the swift-water type were very abundant. Among the May-fly nymphs collected there were found about a dozen specimens of one species which presented a curious appearance. Upon examining some of these nymphs it was found that each one carried upon its back a large, white dipterous larva. These larvæ had attached themselves to the thorax of the nymphs underneath the wing pads. The large size of the larva forced the wing pads of the May-fly nymph upward at a very decided angle and gave the nymph a humped-up appearance as it rested upon the stone.

All the collected material was preserved in alcohol and taken back to Ithaca, N. Y., for study. When the material was examined more closely in the laboratory, some of these May-fly nymphs were found to carry larvæ, while others of the same species carried pupæ of the dipterous insect.

The May-fly nymph proved to be a species of the genus *Rithrogena*. Although it was impossible to determine definitely the genus of the dipteron, Dr. O. A. Johannsen, who examined it, felt certain that it belonged to the family Chironomidæ. The scarcity of material and the lack of adult forms, however, made it impossible to sat-

* Read before the joint session of the Entomological Society of America and Ecological Society of America, January, 1922. Withdrawn for publication in this bulletin.

isfactorily establish the relationship which existed between these two forms.

During the summer of 1921 the writer made another trip to Estes Park, Colo., and again found these May-fly nymphs in the same situation in the Big Thompson river where they had previously occurred. A careful search was then made over a distance of a mile or more in this stream, but there was only this one particular spot in which the *Rithrogena* nymphs could be found in considerable numbers. This was in a part of the stream where the current was quite swift and the water not over six to ten inches deep. The bed of the stream was covered with stones, many of the stones projecting above the surface of the water. May-fly nymphs, stone-fly nymphs, caddis worms and other swift-water forms were very plentiful. As many as five or six specimens of the *Rithrogena* nymphs occurred on a single stone. Upon taking a stone out of the water and turning it over, these nymphs would quickly glide to the under side of the stone, appearing to be much more elusive than any of the other species of the May-fly nymphs present. A total of nearly 300 of the *Rithrogena* nymphs were collected, and more than ninety per cent of them were found to carry either a larva or a pupa of the chironomid.

An attempt was then made to rear to the adult stage the May-fly and the chironomid. In order to accomplish this a number of the nymphs which carried pupæ were placed in small wire cylinder cages. Some of the cages were placed in the part of the stream where the nymphs naturally occurred, while others were placed in a spring near the writer's cottage, where they could be kept under close observation. Three males of the chironomids emerged on August 7, two of them from cages in the stream and one from a cage in the spring. A female also emerged on the same date, but it escaped. On August 8 two males of the May-fly emerged, one from a cage in the stream and the other from a cage in the spring. On the previous day two females of the May-fly were caught in a net near the same spot where all the material was collected, and these later proved to belong to this same species.

The necessity of leaving the park on August 8 prevented any further rearing work, and the material from the cages was added to the alcoholic specimens and taken back to the laboratory at Cornell University.

The May-fly has been determined by Dr. J. G. Needham, who recognizes it as a new species of the genus *Rithrogena*. A descrip-

tion of this species will be given by Doctor Needham in a paper which is soon to be published.

The chironomid is a new species of *Trissocladius*, a genus new to this country.*

DESCRIPTION OF THE STAGES OF THE CHIRONOMID.

Trissocladius equitans n. sp.

ADULT.

Length, 4.5 mm., exclusive of antennæ. General color, blackish brown.

Head blackish; eyes black, naked, slightly emarginate on inner margins, the facets moderately rounded; distance between the eyes from above greater than the length of the eye. Labium short, thick, and reaching to the second segment of the palpi. Palpi short, three-segmented; the first segment nearly twice as long as broad; second segment twice as long as broad; third segment gradually tapering to the tip and a little longer than second segment; total length of palpi about .25 mm. Antennæ composed of fourteen segments, the terminal one-half again as long as the combined length of segments two to twelve; basal segment large; second segment about twice as long as third; total length of antenna 1.3 mm.; entire antennæ covered with long hairs, the basal hairs as long as the terminal segment. Epistome without bristles; transverse suture distinct.

Thorax blackish brown, with whitish pruinose patches; dorsum with a narrow median line, depressed in front and raised into a feeble carina behind the middle; surface smooth except for a few hairs on each side of the broad, flattened longitudinal area of the mesonotum; collar incised in middle, angles rounded; scutellum and metanotum blackish, smooth; plura and pectus blackish, smooth.

Abdomen compressed, blackish, with long, yellowish hairs; basal segment of the male clasper about twice as long as the distal segment, spoon-shaped, the median projection or tubercle blunt, with short hairs, basal segment below with long hairs; distal segment narrow at base and gradually enlarging toward the apex, a few hairs above and underneath with two short spines near the tip.

Wings milky white, reaching to the base of the claspers; surface finely punctate; anal lobe produced and fringed with long hairs; venation as in figure 14.

Halteres pale, slightly infuscated.

Legs light brown, hairy; tibia of front leg 1.4 times the length of metatarsus; a single distinct spur at distal end of tibiæ, the ones on the posterior legs being much larger; fourth and fifth tarsal segments of equal length; tarsal claws squarely truncate, surface fluted; no pectinate empodium present.

Type in the Cornell University collection, now mounted in balsam. Paratypes, two males; one a pinned specimen, the other in alcohol, in the Cornell University collection.

These specimens are all from Estes Park, Colo., August 7, 1921.

---

*Acknowledgments are due to Dr. O. A. Johannsen, who recognized this as a new species, and without whose assistance the following descriptions could not have been adequately made.

LARVA.

Length, 6-7 mm. when fully grown. Color white.

Head very small, not over .25 mm. in diameter. Prothoracic proleg double, short, with many short spines; caudal prolegs short, each with a ring of about 24 short spines. Anal gills not apparent.

Head yellowish brown, with a narrow black hind border; on the ventral surface of the head, near the hind border, there is on each side a light oval spot, suggestive of an ocellus. Mouth parts very small and difficult to dissect out; they are much reduced in size; the mandibles are composed of a single sharp tooth with two short spines on the inner margin near the base of the tooth; labrum small, the front margin excavated in the middle so as to leave a bluntly rounded chitinized tooth on each side; labial palpi very short; antennæ minute, easily overlooked.

PUPA.

Length, 5-5.3 mm. Color brown; a narrow, blackish margin around the wings, and a narrow longitudinal dark line each side of the abdomen. The entire pupa is smooth and devoid of any vestiture. Breathing trumpets not well developed, but represented by a spiracularlike chitinized area each side of the mesothorax. These breathing trumpets are best seen in the late larval stage when the pupa is being formed (fig. 7). Segment one to three of the abdomen smooth; segments four and five, above, each with a double transverse band of fine spines on the posterior margin, the spines of the hindmost bands directed forward and at least twice as long as the spines on the band immediately in front; segments six, seven and eight each with a single transverse band of short spines. Genital sacs smooth, no hairs or spines present. On the lateral margin of the abdominal segments the vestigial spiracles are visible

THE BIOLOGICAL RELATIONSHIP

Between *Trissocladius equitans and Rithrogena* sp.

With plentiful material on hand it has been possible to establish the relationship which exists between the immature stages of these insects. The larva of *Trissocladius equitans* is parasitic upon the *Rithrogena* May-fly nymph. Although it has not been possible to learn in what manner the larva establishes itself as a parasite on the nymph, indications are that *Trissocladius equitans* spends its entire larval life as a parasite upon the May-fly nymph. Different-sized larvæ, representing the instars, except possibly the first, were found under the wing pads of the nymphs.

The parasite attaches itself to the posterior margin of the mesothorax underneath the wing pads, where it imbeds its head in the softer tissue of the nymph and where it draws its nourishment from the host. The larva spins a sheet of silk, which completely invests its body, and by means of which it attaches itself firmly to the body of the nymph. At first, stretched to its full length, the larva

lies across the body of the nymph, but as it grows larger the posterior end of the body doubles under, and later, when the larva becomes full grown, the middle part of its body projects backward over the abdomen of the nymph in the form of a letter U. When ready to pupate the larva releases its hold at the head end and turns back over the abdomen of the nymph. The pupa thus extends over about half the abdomen of the host. The transparent sheet of silk invests the pupa as well as the larva. Just before the adult is ready to emerge the pupa breaks through this investing membrane and rises to the surface of the water, where the adult emerges in a manner similar to that in other chironomids.

That the larva is a parasite upon the nymph is apparent from the following facts: First, the silk membrane completely surrounds the larva. There is no opening in this membrane which would make it possible to obtain food from the outside. Second, an examination of the stomach contents of a number of larvæ failed to reveal the presence of any vegetable material, but did contain animal matter, especially fat bodies. This fact was also borne out in a study of cross sections of the larvæ. Third, a study of the head and mouth parts of the parasite reveal their reduced condition. The head is very small in proportion to the size of the body and the mouth parts are much reduced.

The European species of the genus *Trissocladius*, of which the larvæ are known, are all found as free living forms feeding upon vegetable matter.*

The reduced size of the head and mouthparts of *Trissocladius equitans* indicate that this parasitic relationship has existed for a long time. Whether the parasite ever becomes so injurious as to kill its host the writer has not been able to determine. Another question of interest is what happens to the parasite when the nymph casts its skin. The life cycle of the parasite is either so short that development is completed during a nymphal instar of the host, or else the parasite must be able to detach itself from the cast skin and reëstablish itself upon the newly emerged nymph or upon another individual, otherwise it must perish.

There appears to be no relationship between the relative ages of the host and parasite. Pupæ of the parasite were found upon medium-sized nymphs, while, on the other hand, young larvæ occurred upon nymphs that were evidently in the last nymphal instar.

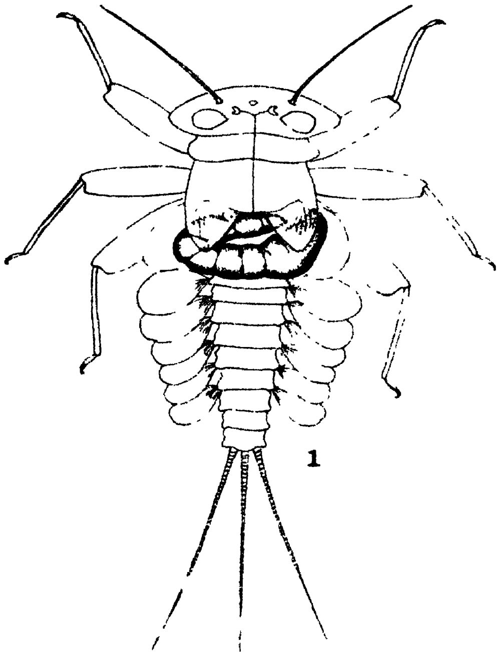
*Barnard, K. H., in the Entomologist's Monthly Magazine, vol. 47:76-78, 1911, reports the case of a chironomid larva (name not given) which is parasitic upon a fresh water snail, *Limnæa peregra*.

PLATE XLI.

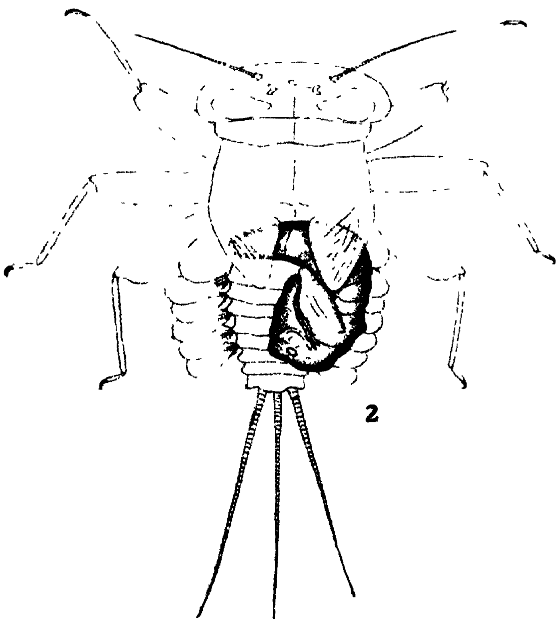
FIG. 1. *Rithrogena* nymph with a larva of *Trissocladius equitans* under the wing pads.

FIG. 2. Nymph with a pupa.

PLATE XLI.



1



2

PLATE XLII.

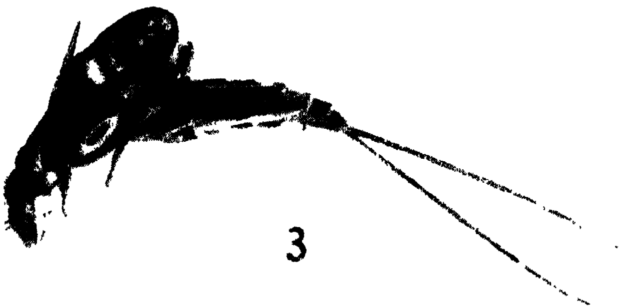
FIG 3 Side view of May-fly nymph, showing the chironomid pupa under the wing pads.

FIG. 4 Young larva of *T. equitans* under the wing pads of the nymph

FIG. 5. Full-grown larva on the nymph.

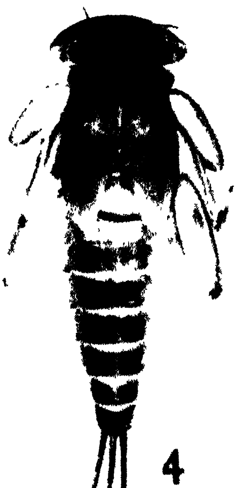
FIG. 6. Pupa on the nymph.

PLATE XLII.



3

5



4

6

PLATE XLIII

FIG. 7. Full-grown larva of *T. equitans*. In the thorax may be seen the breathing trumpets of the developing pupa within

FIG. 8. Mandible of the larva of *T. equitans*.

FIG. 9. Labium of the larva

FIG. 10. Hind proleg of the larva.

FIG. 11. Portion of the abdomen of the pupa

FIG. 12. Adult, *T. equitans*

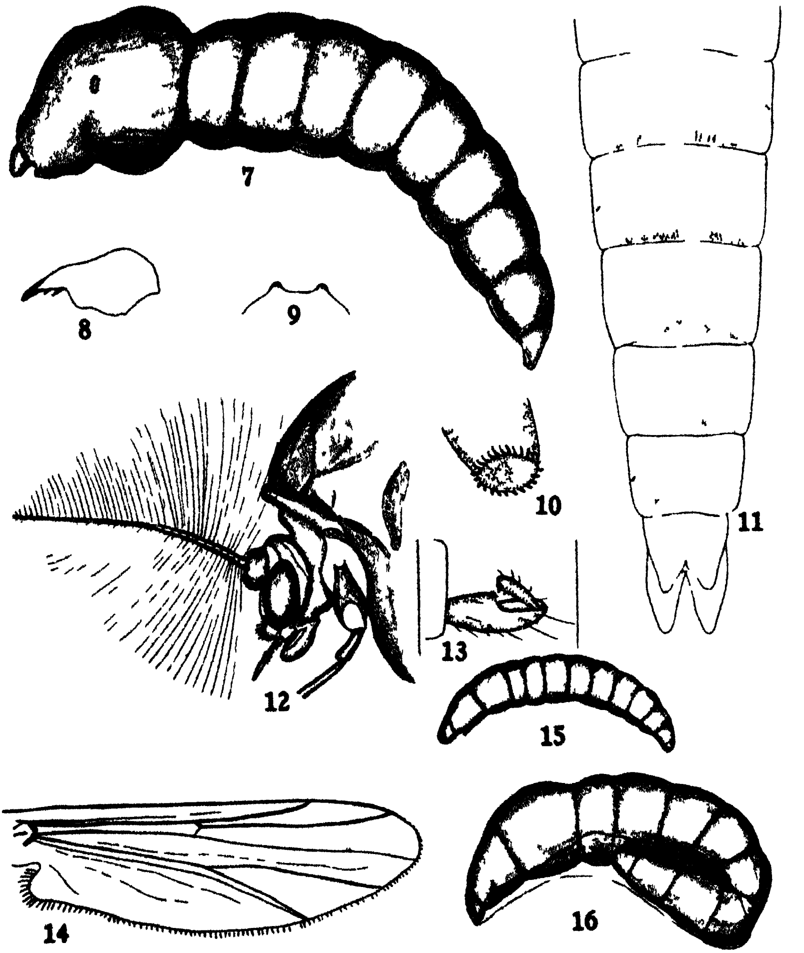
FIG. 13. Clasper of male

FIG. 14. Wing of male.

FIG. 15. Young larva

FIG. 16. Nearly full-grown larva The black line indicates the edge of the silk membrane which envelopes the larva and by means of which it is attached to its host.

PLATE XLIII



THE

KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV, No. 17—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 17.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 17.

Water Insects from a Portion of the Southern Utah Desert.

BY R. C. MOORE,
Professor of Geology, University of Kansas; and
H. B. HUNGERFORD,
Professor of Entomology, University of Kansas

INTRODUCTION.

THE COLORADO PLATEAU.

Not the least interesting of that well-known and yet little known country of varied attractions, the Great Western Cordillera of America, is the region of lofty plateaus, towering cliffs and deep, impassable canyons which is known as the Colorado plateau. Bordered on the east by the snow-clad peaks of the Rocky Mountains, on the north by the Uinta mountains, and on the west and south by low-lying deserts of the Great Basin and the lower Colorado valley, the Colorado plateau includes most of western Colorado, eastern and southern Utah, northern Arizona and northwestern New Mexico. Unlike the serrated peaks, irregular jagged spurs and sharp-topped divides of the Rockies, or of the mountain ranges in the Great Basin and Arizona deserts, the plateau country is a land of elevated, essentially flat-topped tables, which are terminated for the most part in steep, irregularly trending cliffs, and of great canyons which, converging on and culminating in the world-famous canyon of Colorado river, ramify almost every section of the plateau province. The tablelands are formed by hard rock formations which lie in more or less nearly horizontal positions, and the steep cliffs which border the plateaus or wall in the canyons mark the edges of these hard formations. Exceptions to the general architectural scheme of the Colorado plateau country are a few small mountain masses of igneous origin, volcanic cones like the San Fran-

cisco mountains in Arizona, or laccolithic intrusions like the Henry mountains in southern Utah. These are not important in the aggregate, but are striking on account of contrast.

All of the Colorado plateau region is arid or semiarid. There is little rain, and most of that which does come falls during a small part of the year and in torrential showers. Much of the characteristic topography and the aspect of the country in general is due chiefly to this.

THE HIGH PLATEAUS OF SOUTHERN UTAH.

The features and the conditions which are broadly typical of the Colorado plateau as a whole find especially characteristic expression, and, indeed, culminate in the south central part of Utah and adjacent portion of Arizona. From the Grand canyon of Colorado river, the most profound and prodigious of the canyons, the stratified rock platforms rise tier on tier like gigantic stairs ascending northward. The top "stairs," in southern Utah, have an elevation of more than 10,000 feet above sea level, and comprise the so-called high plateaus. It is almost inevitable that this lofty plateau country, so closely adjacent to the deepest of the canyons, should be intricately dissected by tributary canyons. The high plateaus and adjoining region may therefore be specially designated as the "canyon lands." Travel is by tortuous and extremely toilsome routes, now in the depths of a profound abyss, now crossing a plateau spur of mountainous proportions. Some areas are absolutely inaccessible, and large districts are almost unexplored. Population is confined to a very few of the accessible valleys where irrigation permits cultivation of a little of the land adjacent to the water supply. Aside from these outposts of determined agricultural skill and industry, the region is traversed only by occasional cattlemen, prospectors or explorers.

CLIMATE.

The two main features which characterize the climate of southern Utah and affect more or less directly the life of the region, as well as physiographic processes, are dryness and temperature variation. In part of the area rainfall is less than five inches in the year, and in all of it the average is less than ten inches per year. In general, there is most rain in the three summer months, July August and September; and least rain in the spring months, April, May and June. The fall and winter months have an intermediate rainfall. The effect of the dry spring season, when most plants begin to develop rapidly and when many of the animals, especially the insects, pro-

gress swiftly through early life stages toward the vigor of midsummer maturity, is to retard or to inhibit the development of life. Seeds may germinate, but, without rains, growth lags or ceases. Larvæ of insects, polliwogs, and whatever animal life is dependent on waters, are restricted to permanent pools, springs or streams, for there are no temporary breeding waters in the dryness of the spring. The distribution of the yearly precipitation at four stations in the vicinity of the localities described in this paper, is shown in chart on page 412.

The temperature of the plateaus is influenced to a large extent by the clear, dry atmosphere and by the altitude. During the days the sun warms the air and the ground, and the bare rocks reflect the heat rays back into the air. At night radiation is rapid and the temperature quickly falls. This large diurnal range in temperature is characteristic of arid or semiarid regions. At Tropic, in central western Garfield county, a freezing temperature in each of the twelve months has been reported, while the maximum temperature is greater than 100 degrees. (See chart, page 413.)

AVERAGE MONTHLY AND ANNUAL PRECIPITATION IN INCHES AT UNITED STATES WEATHER BUREAU IN REGION OF THE COLLECTIONS

STATION.	County	Elev	Years	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct.	Nov.	Dec.	Annual.
Escalante	Garfield	5,700	1901-'18	1 34	1 01	1 14	0 50	0 45	0 50	1 66	1 71	1 07	1 12	0 47	0 72	11 69
Hite	Garfield	3,000	1902-'14	66	68	70	36	50	31	49	63	73	75	78	69	7 28
Tropic	Garfield	7,000	1897-18	1 17	1 05	90	71	63	37	1 47	1 51	1 20	78	79	1 00	11 58
Kanab	Kane	4 925	1903-17	1 82	1 39	1 72	1 19	66	26	1 30	77	79	87	1 28	78	12 83

HIGHEST AND LOWEST TEMPERATURES FAHRENHEIT

Station	County	Elev	Years.	Jan		Feb		Mar		April		May		June		July		Aug		Sept		Oct		Nov		Dec.		Annual.	
				H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H.	L	H.	L.
Escalante	Garfield	5,700	13	61	-17	84	11	80	10	83	13	92	25	98	31	98	38	97	32	90	22	87	16	72	1	62	-15	98	-17
Hite	Garfield	3,000	14	66	1	81	6	86	18	94	28	104	35	111	40	115	44	110	51	104	39	91	29	76	19	76	-1	115	-1
Tropic	Garfield	7,000	20	67	-2	67	-32	74	0	84	6	96	13	100	20	101	32	101	30	100	11	84	10	72	-9	76	-15	101	-32
Kanab	Kane	4,925	9	62	15	70	8	85	1	87	8	101	16	101	23	105	39	101	35	95	24	89	9	79	10	66	-11	105	-15

SURFACE WATERS.

Though the topography of southern Utah is very evidently the result chiefly of erosion by running water, there are few perennial streams in the region. The Colorado, master stream of the plateau country, gathers the waters from the west slopes of the Rockies, from the Uintas and other ranges where rains and melting snows furnish a varying but unending water supply. The tributaries which unite to form the Colorado begin, for the most part, as clear mountain streams, but in southern Utah the river carries so heavy a load of mud and sand that the water is dark reddish brown. On this account the name Colorado was first applied. The river is large and swift, with swirling eddies and numerous rapids. The only permanent tributaries to the Colorado in southern Utah are San Juan river on the south and Dirty Devil and Escalante rivers on the north. Each of these streams flows in a deep canyon, and, except for size, is essentially similar to the Colorado. The Escalante, which is the main stream in the region from which most of the collections of insects were obtained, is fed by the melting snows, rains and springs of the southern extremity of the highest of the plateaus, the Aquarius. Its waters are somewhat clearer than those of the other streams, because most of its course lies through massive sandstones.

The numerous smaller streams in southern Utah contain water only at times of local rainfall. The run-off is very rapid, and after a torrential, muddy flood of less than an hour, or at most a few hours, the flow ceases. This type of swift, intermittent streams is characteristic of all the plateau region.

After rains there are in places pools or "tanks" in such natural hollows as may retain any of the water. Some of these are found in the stream channels, others in eroded depressions in the naked rock. Some are small, shallow and short-lived under the rays of an intense sun and a thirsty atmosphere; others are larger, and occasionally deep. Those in the channels of streams commonly contain very muddy water, which, because of the excessive fineness of the mud, retains the sediment in suspension until evaporation gradually gives it the consistency of thick soup or gravy, and finally of brick. Where the rain water accumulates in sandstone, or where the gathering waters do not cross exposures of the soft shales which furnish most of the muds, the waters remain fairly clear. The larger "tanks" may retain water from year to year, shrinking slowly through times of drought, but refilling on the

coming of rain. These little pools of moderately clear water afford sanctuary for such water-breeding or water-living animals as inhabit the region, and in some cases it is a populous and assorted community that crowds together.

Springs may be mentioned among the surface waters of southern Utah, although they are not numerous, and the water from them very shortly sinks into the ground. They are in many cases nearly permanent, and are an important source of supply, especially as regards the uses of man. None of the springs or seepages in the plateau region studied has a flow of more than a few gallons an hour.

It is frequently a number of miles from one spring, "tank" or other permanent water source to another.

FIELD WORK

In the summer of 1921 and 1922, Mr. Moore, with a party of four assistants, was assigned by the United States Geological Survey to make an examination of a portion of the high plateaus of southern Utah, with reference to coal resources and possibilities of oil and gas development. A detailed geological map of approximately 3,000 square miles was made, and reconnoissance study of a very much larger area was completed. The region mapped comprises most of central eastern Garfield county, a portion of central Wayne county, and eastern Kane county, Utah. Although the primary purpose of this work had to do with possible coal, oil and gas resources, special attention was given to water supply, for the region is a semidesert. Not only was it important for the party to find water for camp purposes, but the possible development of water supply is in all cases the most important consideration in the utilization of such a region. During the course of this work, wherever water insects were found, and where it was possible without interruption of the main objects of the work, collections were made. Since no other similar collections have been reported from this region, and since the distribution of water insects in this region is both of biological and general entomological interest, the results are here presented. Identification and special notes on the species found are the work of Mr. Hungerford.

DESCRIPTION OF COLLECTIONS.

Since the collections of water insects to be noted below were gathered as opportunity offered and not as a part of a systematic faunal survey, the data are perhaps somewhat fragmentary and scattered. However, since the sources of water supply in such

country are not numerous, and since it is necessary for the traveler, whatever his mission, to seek the places where water may be had, it is probable that a considerable number of the places where water insects might occur were observed. In each of these a collection, representing as far as possible all of the species present, was obtained. The collections include mainly those from springs and "tanks." It is possible that water insects could have been found in some of the seepages along streams or in the permanent streams, but there was no opportunity to make special search for these.

SMALL "TANK," ONE AND ONE-HALF MILES ABOVE MOUTH OF MULEY TWIST CREEK, EASTERN GARFIELD COUNTY, UTAH.

Muley Twist creek is an intermittent stream whose bed is dry the greater part of the year. It occupies a very deep box canyon, carved in massive red and yellow sandstone. About seventy-five feet above the bottom of the canyon, on its sloping west sandstone wall, was found at one point about one and one-half miles above the mouth of the creek, a little "tank" about one by two feet in width and length and with greatest depth of approximately one foot. The depression was filled with clear water, part probably caught in a recent rain and part derived from a very small seep in the sandstone above. The "tank" is probably not at all permanent. It was surrounded by bare smooth sandstone, without any near-by plant growth.

In this little basin lived a group of seven individuals of *Arctocorixa abdominalis* Say, without other insect life.

"TANK" ABOUT TWO MILES ABOVE MOUTH OF MULEY TWIST CREEK, EASTERN GARFIELD COUNTY, UTAH.

On the east side of the Circle Cliffs and along the Water Pocket Fold in eastern Garfield county are a number of "tanks" which contain water in all but the driest seasons. From one of these, in the bed of Muley Twist creek, beneath a high sandstone cliff, a number of water bugs were taken. The pool was about eight feet in diameter and three feet deep in one part at the time of our visit in August. Two or three large cottonwoods shade the pool, but there is almost no other vegetation near at hand.

In this little basin was taken one dytiscid beetle, *Rhantus binotatus* Harr., and upon the surface eight specimens of *Gerris orba* Stal, all winged, and one pair mating (five males and three females). The solitary dytiscid beetle appears to be a new record for Utah. Its previous capture has been recorded for Wisconsin and Arizona.

"TANK" ON COLORADO RIVER AT WATER POCKET FOLD, KANE COUNTY.

This was located on the north bank of the Colorado river near the mouth of a small tributary canyon at Bennett's oil camp, where Water Pocket Fold crosses the canyon of the Colorado river, about eight miles above the mouth of Escalante river, eastern Kane county. A pool of clear rain water filled the depression in bare sandstone, about four feet wide, five feet long and two and one-half feet deep; no vegetation around the pool; about thirty yards from Colorado river, a swift, muddy stream, very unlike the water in the "tank"; unknown distance to adjacent pools of clear quiet water; elevation about 3,500 feet. Here were taken:

Fifteen *Arctocorixa abdominalis* Say, four males, eight females and three nymphs. This represents the farthest north record for the species, which was described from Mexico and reported from Texas and California by Uhler.

One *Notonecta insulata* Kirby, female.

Two *Thermonectes marmoratus* Hope, one male and one female. The capture of this beautiful dytiscid appears to be a new record for the state. Leng's catalogue records it from Arizona and Lower California.

SPRING OPPOSITE OWL CAVE, HARRIS WASH, GARFIELD COUNTY, UTAH.

About twenty miles southeast of the little town of Escalante, eastern Garfield county, Utah, a permanent spring is found in the sandstone wall of Harris canyon, which is tributary to Escalante river. The flow of this spring is not large, but the water is of excellent quality, and, as natural shelter is conveniently near at hand in a large sandstone cavern, Owl Cave, the spot is a camping place for most of the few travelers who pass this way. The water from the spring irrigates naturally several square yards of protected ground adjacent to the spring. A beautiful little meadow, therefore, has been formed, through which the water flows a short distance before sinking into the sand.

This spring and short stream support a populous community of aquatic insects and other life. However, only two species of water bugs were observed, *Gerris remigis* Say and *Trepobates pictus* Uhl.

SPRING IN WATER POCKET FOLD, CIRCLE CLIFFS, GARFIELD COUNTY, UTAH.

One of the very few water sources in the northeastern side of the Circle Cliffs is a small spring, from which the water flows a few yards before disappearing in the floor of a canyon tributary to

Muley Twist creek. The adjacent rocks, chiefly sandstone, are nearly bare of vegetation, though not far distant are numerous piñon, scrub cedar and sagebrush. The spring varies somewhat in volume, but does not commonly dry up in the spring dry season.

On the surface of the spring and the little stream below are numerous representatives of the species *Trepobates pictus* and *Gerris remigis*. A large number of individuals of each were obtained, including a considerable number of nymphs belonging to the first species. The *Trepobates* were more numerous than the Gerrids at the time of observation in August, 1921—a rather unusual condition as compared with other localities inhabited by the two forms.

SPRING ON UPPER HENRIEVILLE CREEK, SOUTH CENTRAL GARFIELD COUNTY, UTAH.

An area of special scenic and geologic interest in southern Utah is Table Cliff and the surrounding very rough district in south central Garfield county. South of Table Cliff, on one of the branches of upper Henrieville creek, is a seepage of very alkaline water, the only source available for camp use in the head canyons under the cliff. The water is so strongly mineralized as to be hardly potable.

On the surface of the short, trickling stream below the seep several water bugs were taken. A few *Gerris remigis* Say and a considerable number of *Microvelia* are the inhabitants of this apparently inhospitable haven. The *Microvelia* species of this region has not been determined. It may be new.

"TANK" NEAR SOUTH POINT OF KAIPAROWITS PLATEAU, EASTERN KANE COUNTY, UTAH.

Most of the observed watering places in southeastern Utah did not contain water insects at the time of visit in the summer of 1922. Of four springs and pools on the top of Kaiparowits plateau, a high tableland which extends southeastward toward Colorado river from the uplands farther north, only one appeared to contain any aquatics. This was a partially rain-filled "tank" in the bottom of one of the narrow, steep-sided canyons which cut the plateau surface. The "tank" was carved in bare, massive sandstone, without near-by vegetation. The pool was about six feet long by one foot wide, and its maximum depth a little over one foot. In this pool were several *Notonecta insulata* Kirby, but no other water bugs.

LAST CHANCE CREEK, EASTERN KANE COUNTY, UTAH.

In a part of the sandstone canyon of Last Chance, about twenty-five miles above the point where it flows into Colorado river, a small stream flows more or less permanently. Other parts of the canyon contain intermittent flow, but in most cases, except for occasional groups of *Gerris remigis*, did not contain other observed water bugs. At the place described, a group of small dytiscids, a number of *Microvelia* and some gerrids were collected.

SPRING ON PARIA RIVER, ABOUT FIFTEEN MILES BELOW CANNONVILLE, KANE COUNTY, UTAH.

Most of the lower Paria river, the main stream in south central Kane county, Utah, is dry the greater part of the year. The river has carved a very deep sandstone canyon, which affords the only passageway from north to south across this part of the country. At a point about fifteen miles below the town of Cannonville, the last settlement on the southward route to Colorado river, at Lee's Ferry, about seventy-five miles distant, is a fine spring. The flow is fairly large, as compared with other springs in this country, and the water is clear and not alkaline.

A host of *Gerris remigis* and *Trepobates pictus* were found on the water of the spring.

LOWER ROCK CREEK, EASTERN KANE COUNTY, UTAH.

Water flows more or less permanently in the lower part of Rock creek, the easternmost of the longer, deep canyons tributary to Colorado river west of Kaiparowits plateau. The canyon of Rock creek, as the name perhaps suggests, is somewhat unusual, even among the great, bare rock cliffs and canyons of the plateau country. Its walls and bottom are mostly composed of naked rock, and sculpture by running water has produced an almost indescribably rough topography.

The stream at the camp site of the writer, about two miles above Colorado river, contained numerous *Microvelia* and a few gerrids. No other water bugs were observed.

NEAR GOODRIDGE, SAN JUAN COUNTY, UTAH.

In a small, isolated spring, about one foot in diameter and a few inches deep, were taken three *Notonecta insulata* Kirby. No other water insects were present. This tiny basin of water was three miles from the swift, muddy San Juan river, and there were no other near water sources known. The location of the spot is at the west side

of Comb Ridge, where the road from Bluff to Goodridge enters Comb Wash. Some vegetation was growing about the spring.

To the above Utah collections may be added this interesting one from northwestern Colorado, made in 1920.

JUNCTION MOUNTAIN, YAMPA RIVER, NORTHWESTERN COLORADO.

In the deep canyon of Yampa river, where the river plunges through Junction mountain, about thirty-five miles east of the confluence of the Yampa and the Green, in northwestern Colorado, were taken forty-four *Rhagovelia distincta* Champ., all apterous; nine were males, four nymphs, and the remainder females; also seven *Trepobatopsis trux* Bueno, two males and five females, described by Mr. Bueno as new.

From a small, sluggish stream at west side of Junction mountain were taken an interesting series of large gerrids. These vary in color from russet to the dark color typical of *Gerris remigis* Say. The russet-colored form has been determined by Mr. J. R. de la Torre Bueno as *Gerris orba* Stal. Of these there are nineteen specimens, nine males and ten females. Thirteen of the lot are apterous. *G. orba* Stal has been listed from California, Oregon and Nevada hitherto. The others, forty-seven of them, all apterous, are of a trifle lighter color than *G. remigis* Say, but obviously are the same as Bueno's *orba*.

In an attempt to find differences between our common *Gerris remigis* Say and this series from the West, all of the Kansas and Colorado material available (a series from the eastern margin of Kansas through the state and across Colorado) has been very carefully studied. The Kansas forms are darker and larger as a series, but it does not seem possible at the present time to fix upon any structural characters to distinguish these forms

In connection with the problem of separating the striders, it may not be out of place to state that it seems to have been overlooked that *Gerris conformis* Uhl. males have the ventral side of the sixth abdominal segment singly emarginate, like *Limnoporus rufoscutellatus* Latr. Indeed, the two species have, in addition to the above genital character, another distinctive character that is common to both, namely, their very long legs. The hind femora in both species greatly surpass the tip of the abdomen. The examination of such material as has been available suggests that the two species commonly accepted as *L. rufoscutellatus* and *Gerris conformis* Uhl. may be separated as follows:

A. Antennal segment 1 longer than 2 plus 3. Eyes protuberant. Middle and hind femora about equal in length. Venter of sixth abdominal segment in male with median longitudinal fossa. The seventh with a longitudinal ventral carina. *Gerris conformis* Uhl.

AA. Antennal segment 1 shorter than 2 plus 3. Eyes not protuberant. Middle femora shorter than hind femora. Venter of sixth abdominal segment in male without fossa and seventh segment not carinate. *Limnoporus rufoscutellatus* Latr.

In addition it may be stated that *L. rufoscutellatus* Latr. is a more slender species, and that it is usually of a russet color. *Gerris conformis* Uhl. has the anterior part of the pronotum bearing two prominent papillæ and well-elevated callosities.

It would seem somewhat of a question whether these two species, having in common genital characters and exceptionally long femora, can be placed in separate genera upon the antennal character alone. Structurally they are more nearly congeneric than *G. remigis* Say and *G. conformis* Uhl. The latter belongs with *L. rufoscutellatus* Latr., and the generic characters of *Limnoporus* should be revised.

RÉSUMÉ.

In brief résumé of the above collecting notes, it may be said that the southern Utah desert affords extremely interesting problems for the student of water life. The light annual rainfall, the isolation of the pools and the nature of the water they contain, lend interest to the study of the resident population of the waters. The collections here reported represent the complete insect population of the various pools surveyed. One isolated little spring-fed pool, the size of a washbasin, contained three *Notonecta insulata* Kirby, and no other insects. Another little rain-filled "tank," less than two feet in diameter and a foot deep, located high up on the sloping wall of a canyon, contained seven water boatmen, *Arctocorixa abdominalis* Say, and not another insect. The scant annual rainfall of from five to ten inches, with the exceptionally light fall in April, May and June, works against a large population of aquatics. The water bugs thus utilize every available supply of water. The pools contained the corixids, notonectids and dytiscids, while the striders were found on the springs more commonly than upon the "tanks." The presence of winged species in places remote from permanent water is readily understood. The finding of eight *Gerris orba* Stal, all winged, upon a rain-filled "tank" and forty-seven specimens of the same species along the Yampa river, all apterous, is worthy of note.*

* An interesting note on the factor regulating wing development is suggested by collecting notes on *Microvelia macgregori* Kirk. in New Zealand by Mr. J. G. Myers, in the New Zealand Journal of Science and Technology, vol. V, pp. 6 and 7. He writes that his collections of this insect in the lowlands have been almost entirely apterous forms, while at an altitude of 4,500 feet every capture was winged.

THE

KANSAS UNIVERSITY

SCIENCE BULLETIN

VOL. XIV, No. 18—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 18)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 18.

The Nepidæ of North America.

(Further Studies in Aquatic Hemiptera.)

BY H. B HUNGERFORD.

ACKNOWLEDGEMENTS.

I WISH herewith to acknowledge my indebtedness to those who have rendered assistance in the preparation of this paper, which had its beginning several years ago. I am under especial obligation to Dr. L. O. Howard, Dr. J. M. Aldrich, and Mr. W. L. McAtee for the opportunity they gave me to study in the United States National Museum, where are located some of the types of Doctor Montandon and the Kirkaldy and Uhler collections of these insects. In addition to the material at the United States National Museum, I have been permitted to examine the collections of Mr. J. R. de la Torre Bueno, of Dr. Carl J. Drake and have had, beside our own University collections, abundant material so generously supplied by Mr. W. E. Hoffmann and Doctor Knight, of the University of Minnesota, and by Mrs. Grace Wiley from collections in Texas. Professor Brimley, of Raleigh, N. C., also supplied me with two species for study. Miss Kathleen Doering made most of the drawings and Mr. P. A. Readio and Mr. Raymond Beamer helped me with the photographs.

INTRODUCTION.

The subtle characters and elusive specific differences between the various species of the cryptocerate groups of the Hemiptera have made it difficult to fix specific limits. The students of these groups have resorted, therefore, to comparisons that are beyond the comprehension of the general systematist endeavoring to identify his collection. Such comparative notes become intelligible only after a prolonged study of the insect group concerned, and this condition

has worked against there being a very large number of students who have found the time and inclination to identify the species in such families as the Notonectidæ, Nepidæ and Corixidæ, for instance.

The difficulty encountered by the writer in sorting and naming the aquatic bugs in the course of his biological studies led to a thorough investigation for diagnostic characters of more demonstrable kind than those employed in the literature. It has been the endeavor, therefore, to find and figure characters of such definiteness that anyone with even fair training in close work can be certain of the species he is trying to identify.

The first report upon this work was given under the title, "The Male Genitalia as Characters of Specific Value in Certain Cryptocerata," which appeared in volume XI of the KANSAS UNIVERSITY SCIENCE BULLETIN, December, 1919. In this the writer called attention to these characters in the Naucoridæ, Saldidæ (not a cryptocerate, of course), Gelastocoridæ, Corixidæ and Notonectidæ. The treatment of the genus *Notonecta* was sufficiently complete to be of value to the systematist, because the male genital capsules of all the North American species were figured or described, save two, *N. uhleri* Kirk. and *N. montezuma* Kirk., the former readily recognizable by the description, and the latter exceedingly rare, represented, so far as indicated in the literature, by two specimens in the Hope museum, carefully studied and figured by Champion. (Figure 8, plate XXXI, Science Bulletin XI, figures *Notonecta howardii* Bueno, and fig. 5, plate XXXI, Science Bulletin XI, figures *Notonecta shooterii* Uhl. The one there named *N. lutea* is, of course, *N. borealis* Hussey and Bueno.)

Studies were made upon the Nepidæ and Corixidæ, but were not reported in the first paper, and there was no intention, until recently, of publishing upon the Nepidæ. However, four species of *Ranatra* have been taken in Kansas waters as a result of recent collecting, all new records for the state. The task of naming these water scorpions involves problems in nomenclature and the authenticity of species—matters concerning which there is a difference of opinion among our best authorities.

Mr. J. R. de la Torre Bueno has believed that *Ranatra nigra* Herrich Schäffer 1853, is a synonym of *Ranatra fusca* Palisot Beauvois 1805. The insect which he calls *Ranatra fusca* is large with very prominent eyes, slender anterior legs, and a deep, broad prosternal groove—a very characteristic insect. With this interpretation of

Palisot's species, he described a small, compactly built insect with very broad front femora, as *Ranatra kirkaldyi.*

Dr. A. L. Montandon (Bul. Soc. Sci. Bucharest, XIX, 1910) considers *Ranatra kirkaldyi* Bueno a synonym of *Ranatra fusca* P. B., and concludes that *Ranatra nigra* H. S. is a good species, although he has seen no American specimen that fits the description. Van Duzee follows Montandon.

In a recent issue of the Entomological News (vol. XXXII, p. 273, 1921), under the title "New Records of Aquatic Hemiptera for the United States with Description of New Species," Mr. Torre Bueno again defends his *Ranatra kirkaldyi* and comments on *Ranatra fusca* P. B., describing it so closely that there can be no mistaking the insect, and stating that there is a specimen of this species in the United States National Museum labeled *Ranatra fusca* P. B., by Doctor Montandon. This statement is indeed true.

Through the kindness of Dr. L. O. Howard, Doctor Aldrich and W. L. McAtee, the writer had the pleasure of spending some time at the United States National Museum studying the aquatic Hemiptera. He had the opportunity, therefore, of examining the material determined by Doctor Montandon, as well as the types of *Ranatra protensa* Montd., *Ranatra brevicollis* Montd. and *Curicta howardii* Montd. He found two distinct species identified by Doctor Montandon as *R. fusca* P. B. One of them is Bueno's *Ranatra fusca;* the other, quite a different species, but not Bueno's *R. kirkaldyi.*

After examining much material in the family Nepidæ, and very carefully studying and weighing original descriptions and comparative notes, the writer has been forced, in spite of his reluctance, to a new interpretation of the old species. The facts which led to the change in nomenclature are presented under the species concerned. All the species are figured in such detail that there need be no question or uncertainty as to designation, and these studies should aid in arriving at a solution of the matters in controversy.

The family Nepidæ is represented in America, north of Mexico, by three genera, *Nepa, Curicta* and *Ranatra,* which may be separated as follows:

A. Body broadly oval and flat. *Nepa.*
AA. Body elongate.
  B. Prothorax a little broader than head, body elongate oval. *Curicta.*
  BB. Prothorax narrower than head, body very elongate. *Ranatra.*

Genus *Nepa,* see p. 428; genus *Curicata,* see p 429; genus *Ranatra,* see p. 433.

GENUS NEPA Linnæus 1758.

We have one species in the genus *Nepa: N. apiculata* Uhl.

Nepa apiculata Uhler.

Uhler, P. R., in T. W. Harris' Insects Injurious to Vegetation, 3d ed., p. 12, plate 1, fig. 1; 1862.

This species was first made known to science through a picture of it which appeared in the third edition of Harris' "Insects Injurious to Vegetation." In this edition Doctor Uhler added notes on the Hemiptera. Then in 1878, Uhler, in his "Notices of the Hemiptera Heteroptera in the Collection of the Late T. W. Harris" (Proceedings of the Boston Society of Natural History, vol. XIX, Pt. IV, 1878), records the presence of "No. 26, Harris Collection, *Nepa apiculata* Say MS., under stones near water, May 15, 1826," and adds the following descriptive note: "The principal differences between our species and the European one consist in the color of the tergum, which is red in the latter, fuscous in ours; and the length of the apical tubes, which in ours are stouter and shorter." In commenting on these comparisons, Montandon (Bul. Soc. Sci. Bucharest, VIII, 1898) says that Uhler, like Stal and Ferrari, attached too much importance to color, and gives illustrations of the variability of *Nepa apiculata* Uhl. and of *Nepa cinerea* L. to prove the danger of considering color of specific significance. He then states that the American species is a little more transverse across the thorax, the abdomen proportionately larger in the rear, and the respiratory tubes shorter than in the European species. Again in volume XVIII of the same periodical, under the title, "Hydrocorises de l'Amérique du Nord, Notes et Descriptions d'Espèces Nouvelles," Doctor Montandon adds that in "*Nepa apiculata* Harris 1862, Uhler 1847,* . . . the superior part of the head is less boldly carinate, especially on the vertex, which is generally almost smooth, quite feebly convex."

These differences between the European *Nepa cinerea* L. and the American *Nepa apiculata* Uhl. do exist, as an examination of the photographs on plate LI will show. However, without both species for study, one would be compelled to remain in doubt or name the species from its geographical distribution. Since there do occur marked structural differences, it is well to note them. The antennæ, for instance, are very different, as an examination of figures 5 and

*Probably a typographical error, because Uhler was born in 1835. Van Duzee omits the reference: Montandon, Bul. Soc. Sci. Bucharest, XVIII, p. 180, from the list under *Nepa apiculata* Uhl. in his catalogue of 1917. It is interesting to note that *Nepa apiculata* was a Say manuscript species.

6, on plate XLVII, will show. The penultimate segment of the European form has a lateral prolongation which gives the antenna a branched appearance. The *Nepa apiculata* lacks this entirely. The male genital capsules are also unlike. The considerable difference between these and between the claspers is indicated on plate XLVII, figures 1, 2, 3 and 4.

The nearest approach to a formal description of the American species is given by Uhler in the Riverside Natural History, vol. II, p. 253, 1884. It follows:

Color dull fuscous gray, with the base of the abdomen above more or less tinged with reddish. It is of an elliptical form, blunt in front, with a ridged middle line on the vertex, and with three short raised lines on the prothorax each side of a longer one on the middle. The surface and margins of the thorax and head are roughly granulated, while these, together with the scutellum and corium, are rough and closely covered with stiff, short pile. The anterior femora have no teeth on the inner angle, but instead there is a prominent elbow, forming a wide expansion for the sides of the deep gutter. The wings are smoke brown, with darker veins. This species closely resembles the European one, and measures about two-thirds of an inch to the end of the abdomen; while the respiratory tubes are a little more than one-fourth of an inch in length.

Montandon has shown the differences between our species and the European *N. Cinerea* Linn.

The United States National Museum has specimens from Massachusetts, Pennsylvania, Maryland and Illinois. I have seen specimens from New York, Minnesota and Wisconsin.

GENUS CURICTA Stal, 1861.

These insects are very interesting because they are intermediate between the broad, flat *Nepa* and the very slender *Ranatra*. The Americas can boast of several species in this genus, but for North America, north of Mexico, there has previously been recorded only one, and of it but a single specimen, taken at Victoria, Tex., just within our limits. From this specimen Doctor Montandon drew up the description of *Curicta howardii*. It is a pleasure, therefore, to record the capture of other specimens of this species and to add a second species which has not been described. This second species has been the subject of life-history studies by Mrs. Grace Wiley, and is reported further on in this bulletin.

KEY TO SPECIES.

A. Lateral prolongation of penultimate segment of antenna very short (see fig. 8, pl. XLVII). *C. howardii* Montd.

AA. Lateral prolongation of penultimate segment of antenna very long (see fig. 7, pl. XLVII). *C. drakei* sp. new.

Curicta howardii Montandon, 1910.

Montandon, A. L., Bul. Soc. Sci. Bucharest, XVIII, p. 181; 1910.

The original description is in French. The writer's free translation follows:

Elongate oval in form, visibly attenuate in front and rear, lateral margins not subparallel, the greatest width toward the posterior third. Head quite enlarged, although a little narrower than the front part of the pronotum, as long as wide, including the eyes, longitudinally carinate throughout its length, the carina more obtuse on the posterior interocular portion. Interocular space more than three times as wide as the diameter of the eye. Eyes small, globular, anterior part of head triangular, exceeding the anterior level of the eyes by a length equal to its width between the eyes in front.

Pronotum distinctly longer than its width behind, lateral edges subparallel on their anterior three-fifths, quite strongly widened on their posterior two-fifths; with four obtuse longitudinal carinæ, little accentuated and subparallel, two each side of the anterior part, the posterior part with two oblique carinæ arising from the anterior median carina and quite divergent behind. The anterior depression of the pronotum broadly semicircular, the anterior angles quite narrowed, subacute.

Scutellum with three longitudinal carinæ, the median continuing quite plainly clear to the apex of the scutellum. The two laterals slightly diverging behind, vanishing on the middle of the sides of the scutellum, which are slightly sinuate before the tip or end.

Coria insensibly and gradually widened behind on their basal halves, attaining their greatest width behind the middle and narrowing thereafter; membrane well developed, regularly subrounded at the extremity. Commissure of the clavus almost twice as long as the scutellum.

Appendages short, quite robust toward the base, attenuated thereafter, about half the length of the abdomen.

Anterior femora quite robust, as long as the pronotum on its lateral edges, with a single median tooth easily visible on the inner edge of the groove where the folded-up tibia is lodged, this tooth distinctly closer to the base than to the apex of the femur; the external side of the groove also appears denticulate, as if notched on the basal third of the femur. Neither teeth nor sinuosities toward the apex of the femur.

Anterior coxæ half the length of their femora. Anterior tibia quite long, blackish, with a pale annulation toward the base, and the apical third likewise pale; the extremity of the tarsi come to the basal third of the femora when the tibia is folded back against the latter.

Intermediate and posterior legs short, the ends of the posterior femora, which are a little shorter than their tibiæ, do not reach the suture of the last abdominal segment. Intermediate and posterior tarsi with their claws less than half as long as their tibiæ.

Median longitudinal part of the prosternum slightly saddle-shaped, projecting in all its width, more elevated than the lateral pieces, a little flattened and traversed its whole length by a fine median groove; very obtusely tuberculate in its anterior part. A greater space between the intermediate coxæ than between the anterior or posterior coxæ.

Length, 19 mm.; maximum width a little behind the middle of the corium,

4.5 mm.; at base of pronotum, 3.8 mm.; length of appendages, 7.7 mm., Victoria, Tex. A single specimen, United States National Museum, Washington.

To the above description Doctor Montandon adds the following helpful comparative notes:

This species is intermediate in size between *C. volxemi* Montd. and *C. scorpio* Stal (=*montandoni* Martin). It differs from *C. volxemi* Montd. by the pronotum being sensibly narrowed in front, while in the latter it is almost as wide in front as behind. In this character it approaches more closely to *C. scorpio* Stal, which also has the pronotum quite narrowed in front, with the same right-angled anterior angles almost sharp, but its anterior tibiæ are, however, slightly more elongated than in this latter species; that is to say, much more than in *C. volxemi* Montd. In the character of the median tooth of the anterior femur being situated closer to the base than the extremity, however, the species approaches *C. scorpio* Stal, but it is plainly separated from the latter by its head being longitudinally carinate throughout its entire length, while the head is simply convex between the eyes in *C. scorpio* Stal and almost plain in *C. volxemi* Montd.

Furthermore, in *C. scorpio* the scutellum is not carinate; the longitudinal grooves of the pronotum are also much less emphasized and the anterior tibiæ are more largely pale, darker only toward the base.

This is the first species of the genus found in the United States. It is to be presumed, however, that others may occur in the Southern states neighboring to Mexico, where are found the two species to which I have just compared it.

I take pleasure in dedicating this to Mr. L. O. Howard, as an indeed feeble expression of my sincere gratitude.

In the collection of Prof. H. G. Barber are three males from Huachuca mountains, Arizona, taken in 1899. They have been compared with the type in the United States National Museum by Dr. Carl Drake, through the kindness of whom I have been privileged to study the structural details of these interesting insects. The United States National Museum has a specimen taken by D. C. Van Dine at Camp Travis, Tex., March 30, 1918.

The species is a compactly built creature. The head is set deeply into the prothorax, the anterior lateral lobes of which are conspicuously swollen and incurved on their anterior tips to embrace a portion of the eyes. The front of the head appears almost truncate, due to the tylus and juga being about equal. The antennæ are small and the lateral prolongation of the penultimate segment short (see fig. 8, pl. XLVII). The pronotum has a broad, prominent elevation throughout its length. On the anterior half of this there is a median longitudinal depression. The genital capsule and its claspers are somewhat different from those of the species described below (see figs. 7 and 8, pl. XLV), but the specific differences are not great.

Curicta drakei sp. new.

Size. Length from 16 mm., in case of smallest male, to 22 mm., in largest female—not counting the respiratory filaments, which are from 7 to 8 mm. long. The width of the head, including the eyes, from 2 mm. to 2.25 mm.; the greatest width of anterior part of thorax, 2.5 mm. to 2.8 mm.; the greatest width of posterior portion of thorax, 3 mm. to 4 mm.; the greatest width of abdomen, 3.6 mm. to 4.75 mm.; the length of pronotum measured along the dorsal median line, 3 mm. to 3.6 mm.

Color. Obscured by incrustations, which color it from gray to black. The cleaned insect is yellowish to dark testaceous, the dorsum of abdomen red.

Shape. Relatively slender; greatest width of thorax is to length of body approximately as 1 is to 5.4. Sides of thorax and abdomen nearly parallel.

Structural characteristics. The head wider across the eyes than distance from caudal margin of head to tip of lora. The length before the eyes greater than that behind them. Eyes small, globular Tylus longer than juga. The head longitudinally carinate.

Penultimate segment of antennæ with long, slender lateral prolongation (see fig. 7, pl. XLVII). The pronotum with anterior lateral lobes not greatly swollen; the lateral margins, therefore, not greatly curved. Three longitudinal grooves on disc of pronotum, the median one broad and straight, dividing the median longitudinal elevation into two parallel carinæ, laterad of which are the deep lunate grooves terminating caudolaterally in deep depressions. The posterior enlarged portion of pronotum bears four more or less distinct longitudinal carinæ, which in some specimens appear to arise as bifurcations of the two prominent carinæ before them, and again as independent elevations. Scutellum tricarinate, the median carina more prominent on posterior half, the lateral carinæ slightly curved and terminating about the middle of the lateral margins of the scutellum, these elevations and declivities often accentuated or obscured by incrustations. Membrane of wings well developed, as long as the elytral suture, reticulate, the apex of the wing covering the basal two-fifths of the genital segment. Operculum of male genital segment semicylindrical and slightly constricted before the apex, which is bluntly pointed and faintly carinate. The metasternal plate short, caudal margin nearly straight, the posterolateral prolongations attaining less than half the length of the coxæ and exposing a large elevated area (as long as wide) of sternite behind it. Front coxa and femur stout, coxa one-half length of femur, which bears its rather well-developed tooth nearer the base than the apex. This tooth is located on the inner edge, two-fifths of the distance from the trochanter to the apex of the femur. Tibia one-half as long as femur, the apex of the short tarsal segment barely attaining the middle of the tooth when tibia is flexed. Mesothoracic femur one-fourth longer than the tibia, which is two and one-half times as long as the tarsus without the claws. Metathoracic femur and tibia of equal length, the tibia about three and one-half times the length of tarsus without the claws, which are one-third the length of the tarsus.

Notes. The above species is described from a series of 20 specimens, 16 of which were collected by Mrs. Grace Wiley in Colorado

county, Texas. Three were taken in New Orleans, La., and belong to Dr. Carl Drake; and one from the state of Coloma, Mexico, is in the United States National Museum. The species is named in honor of Dr. Carl Drake, who believed the species to be new as long ago as 1916, but who never found time to study the matter thoroughly.

Curicta drakei, while measuring as long as *C. howardii*, is a much more slender species, and appears smaller. Indeed, comparing the males of the two species, there is a considerable difference in size and shape. The anterior lateral lobes of the pronotum are much more prominent in *C. howardii*, the sides of prothorax, therefore, more curved. The median longitudinal fossa in *C. howardii* is confined to anterior part of the median elevation. The tylus is longer in *C. drakei*, the antennæ are differently formed (see figures 7 and 8 on plate XLVII), and the metasternal plate is smaller. This new species differs from *C. volxemi* Montd. from Mexico by its smaller size (*C. volxemi* is 24½ mm. long without appendages), by the tooth on the front femur being conspicuously nearer base than apex, while Doctor Montandon's figure of his species shows the tooth in the middle, or nearer the apex. It further differs from *C. volxemi* by having the head longitudinally carinate and the scutellum tricarinate. The thorax is relatively shorter than in *C. volxemi*, which has a thorax twice as long as wide. The front coxæ of *C. drakei* are much shorter.

It differs from *C. scorpio* Stal, which, according to Montandon, lacks the carina on head and scutellum and has the sides of the thorax much as in *C. howardii* Montd. The longitudinal grooves of the thorax of *C. scorpio* Stal are less emphasized than in *C. howardii*, which in turn has them less emphazised than *C. drakei*. All of these points separate *C. drakei* from *C. scorpio* Stal, and are based upon Doctor Montandon's remarks upon the latter species. Champion, in his "Biologia Centrali Americana," places *Nepoidea montandoni* Martin as a synonym of *C. scorpio* Stal. Joanny Martin, under the title "Descriptions d'Espèces Nouvelles de Nepidæ (Hem.)," in Bulletin de la Société Entomologique de France, 1898, pages 66-68, describes on page 68 his *N. montandoni*, and figures the head and thorax on the previous page. *C. drakei* is unlike this species. Stal's description of *C. scorpio* is wholly inadequate.

GENUS RANATRA Fabricius 1790.

This genus is characterized by its very elongate, slender form. It is the dominant genus of the family Nepidæ in North America. Doctor Horvath, in his paper, "Les Relations entre les Faunes

Hémiptérologiques de l'Europe et de l'Amérique du Nord" (Proceedings of the Seventh International Zoölogical Congress, 1907), lists the genus *Ranatra* as belonging to the oriental fauna. Since that time Doctor Montandon has added several names to our American lists.

The species in the genus are superficially so similar in color and general characteristics that there has been much confusion in naming them. The descriptions have been made in several cases from a single specimen, without, therefore, a consideration of variations within the species. They have dealt with comparisons that can be appreciated only after long familiarity with the insects, and on this account many errors of determination have arisen. The most unfortunate circumstances attending the study of North American *Ranatra* has been the failure to recognize the identity of *Ranatra fusca* P. B. 1805 and *Ranatra nigra* H. S. 1853, the descriptions of which are inadequate, and therefore, since the types are not available; can be interpreted authoritatively only through the examination of abundant and representative material from the entire country.

After studying long series of specimens representing a wide distribution, the writer has been compelled by the evidence before him to place a new interpretation upon our North American *Ranatra*. This he has been reluctant to do, because it involves the renaming of our commonest two species. Stability, however, can never be attained in this group by postponing or ignoring the evidence that eventually must prevail.

Ranatra fusca P. B. was described and figured in color, natural size, by Palisot de Beauvois, in his "Insectes recueillis en Afrique et in Amérique, dans les Royaumes d'Oware et de Benin, à Saint Dominque et dans les États Unis, pendant les années 1786-1797."

The figure is not amplified nor enlarged as suggested by Doctor Montandon (Bulletin Soc. Sci. Bucharest, vol. XIX, 1910), who was in error in endeavoring to make *R. kirkaldyi* Bueno, our smallest North American *Ranatra*, fit a drawing that has the dimensions of our largest species. He was mistaken in believing *R. kirkaldyi* Bueno a synonym of *R. fusca* P. B., for there are two convincing reasons for believing *R. fusca* P. B. is represented natural size.

First. Palisot de Beauvois in his "Discours Préliminaire," page xv, says, "J'ai adopté, pour la grandeur des figures, un plan uniforme, et qui m'a semblé plus commode, c'est-à-dire, celle d'un pouce pour tous les Insectes plus petits que cette mesure adoptée, en plac-

ant à côté une ligne perpendiculaire de la grandeur réel le de l'animal. Ceux qui excèdent un ponce seront figurés de leur grandeur naturelle."

Second. The plate which bears the figure of *Ranatra fusca* has upon it three figures natural size (one of which is *Ranatra fusca*) and two figures enlarged. These two have the true length indicated by a line, and one of these, *Naucoris femorata,* of which the writer has specimens, fits the line which was drawn to indicate the true length. There are on the plate three figures of *Belostoma* which Palisot calls "*Nepa,*" male and female, of "*Nepa subspinosa,*" natural size, which are not accompanied by a "line of true length," and *Nepa minor,* accompanied by a line. The drawing of *Nepa minor* is as large as those of *Nepa subspinosa,* and yet the author distinctly says that *Nepa minor* is smaller. The line indicates its true length, and the inevitable conclusion is that the figure of *Ranatra fusca* is natural size. Indeed, a comparison of drawings with the specimens throughout the book shows the author consistently followed his stated policy of drawing large insects natural size and indicating enlargements by lines, whenever made.

Palisot's insects were taken between the years 1786 and 1797. Those from the United States, then, were taken from somewhere in the eastern United States, for the territories of the United States at that time were bounded on the north by Canada, on the west by the Mississippi river, and on the south by the north line of Florida *Ranatra fusca,* therefore was collected within these limits.

Palisot, in his "Discours Préliminaire," alludes to an account of his travels as being in press. I have not located this, but have secured two brief biographical sketches of him; one from "La Grande Encyclopedie," vol. XXV, and the other more complete, from P. Larousse, "Dictionnaire du XIX Seicle 12," page 66. Neither of these mention a book of his travels. From these accounts we learn that he came to Philadelphia first in 1791 to secure assistance against a Negro uprising in San Domingo, where he was taking part in govermental affairs. He seems to have been in the United States for some time, for upon his return to San Domingo he narrowly escaped death at the hands of the blacks (1793). He escaped to Philadelphia without funds and supported himself there by giving lessons in music and language. Finally he secured help from France to make a scientific voyage in North America for new collections, and returned to his own country in 1798. He died in 1820. These brief facts indicate that most of his days in the United States were spent about Philadelphia, and it seems to me probable that many of his insects

were collected in that region. The possibility of his *R. fusca* not being known to us in nature seems to me quite remote.

According to the figure, *Ranatra fusca* of Palisot de Beauvois is a large, robust insect with broad anterior femora and short legs and respiratory tube. The question is, what insect of the range indicated has these characters? After careful consideration of the problem I must conclude that the only one with the proper size, robustness, broad femora and short legs is *Ranatra americana* Montd. It has the variable respiratory tube, usually longer than Palisot's figure, but not uncommonly as short, and in every case shorter than the body. The failure of the artist to indicate any apical tooth on the anterior femur is readily understood, since we know that this character is often obscured by a marginal fringe of pile so completely as to escape any but the closest scrutiny. It is indeed a somewhat variable structure; in some examples much reduced, and in others plainly visible. The writer has in his collection specimens which fit Palisot's figure almost exactly.

The second species with which we are concerned is *Ranatra nigra* H. S. This species was described in 1853 from America by Herrich Schäffer in his "Die Wanzenartigen Insecten." It was described as being from 2 to 2⅛ inches long from beak to tip of respiratory tubes, with the respiratory tubes not much over half as long as the body; indeed, he says they were three-fourths of an inch! Now the only species we have which in a series of specimens has a respiratory tube averaging three-fourths of an inch long is *R. protensa* Montd. Doctor Montandon described his *R. protensa* from a single large female, which, because of its very yellowish color and shorter limbs, did not suggest *R. nigra* to his mind. Indeed, considered alone, it is not at all to be expected that it would. *R. nigra* was described as having the structure of thorax and relative length of limbs as in *R. elongata*. Now, *R. elongata* has very elongate hind femora, the tips surpassing the last abdominal suture by a considerable distance. The length of limb in *R. protensa* Montd. is, on the whole, not as great as in *R. elongata,* but is strikingly longer than in *R. linearis* L., with which he compared it in size, and this suggested *R. elongata*. Indeed in many specimens of *R. protensa* Montd. the hind femora surpass the last abdominal suture. The front legs of *R. protensa* are long and very slender and the thorax is more like that of *R. elongata* than of *R. linearis*. Doctor Montandon said that he had never seen any specimens from North America with legs as in *elongata*. We have three species with limbs relatively as long.

It seems scarcely necessary to mention that the color implied by the name *nigra* has nothing to do with the case, for black coloration occurs in all the species, due to one of two causes—either dark incrustations or deposits upon the integument, or dark discoloration due to failure in drying out the specimens. Either of these causes might account for a uniform dark or black color in a given series of insects.

There are other facts relative to the identity of these species which will be presented under notes after the various descriptions, to which the reader is referred for further evidence. Aside from the points mentioned, the probability of our two commonest and widespread species being first described is of itself very great.

The list of the species of *Ranatra* now known from America north of Mexico is as follows:

Ranatra fusca P. B. 1805 = *Ranatra americana* Montd. 1910.

Ranatra nigra H. S. 1859 = *Ranatra protensa* Montd. 1910.

Ranatra quadridentata Stal 1861.

Ranatra kirkaldyi Bueno 1905 and its variety *hoffmanni*, n. var.

Ranatra brevicollis Montd. 1910.

Ranatra buenoi, sp. new = *Ranatra fusca* Bueno and Mondt. in part.

Ranatra drakei, sp. new.

Ranatra australis, sp. new.

It will be noted that *R. quadridentata* Stal, completely submerged in Van Duzee's catalogue under *R. americana* Montd., is restored. Dr. F. H. Snow, in Trans. Kan. Acad. Sci., vol. XX, pt. 1, p. 153, 1906, was not writing about the species which Doctor Montandon later described as *R. americana*, but another which we believe to be *R. quadridentata* Stal, and should not have been synonymized by Van Duzee. It will also be seen that *R. annulipes* Stal is omitted. This *R. annulipes* Stal is a very distinct species and not to be mistaken for any the writer knows from our range. Doctor Montandon has established, through the examination of types and type material, that *R. fabricii* Guér. is the same as *R. annulipes* Stal. Figures of this species are given in this paper, because it has been cited as coming from our range.

The variety, *edentata* Montd., of *R. americana* Montd., is assumed to be an *americana* with attenuated apical tooth on front femur. Whether it should be recognized as a variety is questionable.

The entire question of the correct names for the *Ranatra* was, as the writer has stated, opened by the necessity of naming four species

from Kansas. The problem was undertaken with no preconceived notions in the matter, except, indeed, a leaning toward accepting Doctor Montandon's studies, since he is a great scholar in the Cryptocerata and was followed by Van Duzee in his catalogue. The results herewith presented may be received with some irritation, because of the revolution necessary in nomenclature, but it seems best for us to get as near the truth as the evidence permits.

In an endeavor to fix the limits of the species, the writer has studied the characters used by the best systematists in the group and in addition, antennal and genital structures. The relative length of body parts, the comparative size of the eyes, the relative length of the limbs and of the caudal filaments, the shape of the sternum and the form of the front femora have been in general use in the attempts to define nature's species in this genus. Species are expected to vary within limits, and breeding experiments with insects show them to vary, not only in single characters, but in linked characters, and in order to steer a fair course between "lumping" and "splitting" species, it is much better to use a combination of three or more characters than to depend too much upon any single one. The use, therefore, of the characters of the antennæ and genitalia is a material aid in the classification of this difficult group.

NOTES ON TERMS USED IN KEYS AND DESCRIPTIONS.

The apical tooth of the front femur is on the inside edge of the front femur near the attachment of the tibia (see fig. 2-A, pl. XLIV). The antennæ are hidden in pockets beneath the eyes (see fig. 9, pl. XLV). The prothorax of *Ranatra* is divided into two parts, anterior and posterior, by transverse lateral grooves (see fig. 2-G, pl. XLIV). The tylus and jugæ are figured on plate XLV, figure 12. The metaxyphus extends back between the hind coxæ as a part of the metasternum. The last abdominal segment is designated as the "genital segment," and its ventral plate in both sexes as the "operculum."

In this paper I have not distinguished between the genital segment and the last abdominal segment, as is often done with some other Heteroptera, where the last abdominal segment is considered the segment just in front of the genital segment. I refer to this as the penultimate abdominal segment (see figs. 10 and 11, pl. XLV).

The male genital capsule of which I speak is, I take it, homologous with what G. C. Crampton in the Bulletin of the Brooklyn Entomological Society, volume XVII, pages 45-55, calls the hypandrium," and the claspers correspond to his "styli," or "gonostyles."

TECHNIQUE USED.

The antennæ are often covered with debris that should be removed. If the antennæ are still difficult to see, the specimen may be relaxed and antennæ moved into view with dissecting needle. The genital capsule of the male lies in the last abdominal segment, entirely hidden. To examine this, relax the specimen in a moist chamber, then holding the specimen on its right side in the left hand, lower the operculum with a dissecting needle and draw out the capsule. A needle with just the very tip turned at right angle is best to use. It can be inserted alongside the capsule, turned so that the hook is against the capsule, and slowly withdrawn, bringing with it the desired organ. If the respiratory filaments start to come also, loosen the capsule from them by inserting the needle between capsule and filaments on each side. The capsule may be removed entirely and mounted upon a card below the insect, or simply drawn into view. The insects are not in the least damaged, and the male capsules may be taken out and operculum pressed back into place by a careful person without it being detected by the closest examination of the exterior.

KEY TO THE SPECIES.

A. Antennæ simple, distal end of the penultimate segment without lateral prolongation. Front femora broad and stout and not narrowed near middle.

B. Front femora without apical tooth or marked sinuosity. *R. kirkaldyi* Bueno.

BB. Front femora with apical tooth or a marked sinuosity. *R. kirkaldyi* Bueno. var. *hoffmanni*, new.

AA. Antennæ with distal end of penultimate segment with a lateral prolongation. Front femora somewhat narrowed in their middle section.

B. The lateral prolongation of the penultimate segment of antennæ not greater than one-half of the length of the ultimate segment. Front femora very slender and without apical tooth.

C. Prosternum with a single wide, deep longitudinal trough. Eyes very prominent. *R. buenoi*, sp. new. (= *R. fusca* Bueno.)

CC. Prosternum without the deep trough, but possessing two longitudinal depressed lines characteristic of most species of *Ranatra*. *R. nigra* H. S. (= *R. protensa* Montd.)

BB. The lateral prolongation of the penultimate segment of antennæ greater than one-half the length of the ultimate segment.

C. Sides of body (connexivum) embracing the operculum of the genital segment at its extremity (see fig. 11, pl. XLV), *R. annulipes* Stal. (= *R. fabricii* Guér.)

CC. Sides of body not embracing the genital operculum at its extremity (see fig. 10, pl. XLV).

D. Pronotum broad and short, anterior enlargement subequal in width to entire head. Anterior femur broad and stout without apical tooth. Median tooth half way between trochanter and tibial joint (measured on inner edge). Metaxyphus very long, extending beyond middle of hind coxæ, nearly attaining abdomen. *R. brevicollis* Montd.

DD. Pronotum more slender. The median tooth of anterior femur nearer distal than proximal end. Metaxyphus not often extending beyond the middle of hind coxæ.

E. Front femur broad without apical tooth.

F. Jugæ of head more prominent than tylus. *R. australis*, sp. new.

FF. Tylus fully as prominent as jugæ. *R. fusca* P. B. (var. *edentula* Montd.)

EE. Front femur with apical tooth.

F. Anterior portion of prothorax fully twice as long as thickened posterior portion. Eyes large, plainly greater than interocular space. Jugæ of head prominent. Front femur long and slender. Hind femur surpassing middle of penultimate abdominal segment. Caudal filaments as long as body. *R. drakei*, sp. new.

FF. Anterior portion of prothorax shorter than above. Eyes not much, if any, greater than interocular space. Jugæ not so prominent. Front femur fairly stout. Middle and hind femora short, not attaining middle of penultimate segment.

G. Eyes prominent, plainly transverse, fully as large as interocular space. Anterior part of pronotum somewhat flattened dorsoventrally. Hind femora short. *R. fusca* P. B. (= *R. americana* Montd.)

GG. Eyes not prominent, neither transverse nor as large as interocular space. Anterior part of pronotum more cylindrical. *R. quadridentata* Stal.

Ranatra kirkaldyi Bueno.

Bueno, J. R. de la Torre, Can. Ent. XXXVII, p. 187, 1905.
(= *R. fusca* Montd., Bul. Soc. Sci. Bucharest, XIX, p. 3; 1910.)

Original description:

Abdominis dorsum orange brown; eyes small, not very prominent; prothorax much constricted at the middle, bisulcate beneath; wings smoky; anterior femora broad with a prominent tooth near the middle, otherwise smooth; posterior tarsi extending beyond the middle of the air tube; air tube shorter than the length of the abdomen; legs banded. Length from tip of abdomen to tip of rostrum, male, 23 mm. to 26.4 mm.; female, 27 to 31 mm.

Notes. This is the species that Doctor Montandon has considered a synonym of *R. fusca* P. B.* Its much smaller size (*R. fusca* P. B. measures 37 mm.) is not the only reason for believing otherwise. The anterior femora of *R. kirkaldyi* Bueno are not constricted near the middle tooth as they are in *R. fusca* P. B. The front legs and respiratory tube are both shorter relatively than in Palisot's figure. This is the smallest known species in North America. It is a characteristic species, quite unrelated and distinct from the others. In the first place, the antennæ are much reduced. They are straight, lacking any projections from the penultimate segment, and often lack anything more than a constriction to distinguish the terminal segment. The ultimate segment is sometimes fused with the penultimate (see figs. 9 and 11, pl. XLVII), but all stages of separation can be found. The male genital claspers are also very distinct, as shown by figure 5 on plate XLVI.

Specimens of this species taken by Beamer and Hungerford in Cherokee county, Kansas, were identified by Mr. J. R. de la Torre Bueno. They agree with the original description in lacking any apical tooth or sinuosity near the apex of the femora. They measure from tip of beak to base of filaments, from 24 to 30 mm., with the filaments from 14 to 17 mm. long. I have seen the true *R. kirkaldyi* Bueno from New York.

In addition to the above Kansas series, I have before me the following series of 127 specimens as follows:

8 Rockbridge, Ohio, 9-30-16, C. J. Drake.
1 Rocky Mount, N. C., 10-19-16, R. W. Leiby.
3 St. Paul, Minn., Phalen Lake, 6-19-21, H. B. Hungerford.
1 St. Paul, Minn., Lake Johanna, 6-26-21, H. B. Hungerford.
4 Ramsey county, Minnesota, 1-9 22, W. E. Hoffman.
7 St. Paul, Minn., Lake Johanna, 10-13-22, W. E. Hoffman.
9 St. Paul, Minn., Lake Johanna, 10-14-22, W. E. Hoffman.
32 St. Paul, Minn., Lake Johanna, W. E. Hoffman.
3 Lincoln, Neb., 1 male, 2 females, W. E. Hoffman.
39 St. Paul, Minn., Water Supply Canal, 10-18-21, W. E. Hoffman.
16 St. Paul, Minn., Lake Johanna, 9-24-21, W. E. Hoffman.
4 St. Paul, Minn., Lake Johanna, 9-17-21, W. E. Hoffman.

I have also seen a series of 170 taken by Doctor Drake in Ohio.

These Minnesota specimens have certain characteristics which set them clearly apart from the Kansas series, yet there can be no mistake in considering them as belonging to the same species. Since I have had a fairly good series of these insects, which are smaller

*See plate XLIX, figures 1 and 2.

than the Kansas forms, more robust, with front femur relatively thicker and possessing a more or less well-marked sinuosity near the inner apex, with antennæ which, on the whole, are blunter at tip, and the subapical tooth of the claspers of male slightly more slender, it seems wise to consider them a variety, for which I propose the name *Ranatra kirkaldyi* var. *hoffmanni.* It will be noted that Mr. W. E. Hoffman has provided me with the longest series of this variety. In a series as large as this, it would seem that if the variety were not fixed there should be found forms like the true *kirkaldyi*, which is described as having "anterior femora broad with a prominent tooth near the middle, otherwise smooth."

Ranatra buenoi, sp. new.

= *R fusca* Bueno, Can. Ent. XXXVII, p. 188, 1905.
Bueno and Brimley, Ent. News, XVIII, p. 438, 1907.
Bueno, Ent. News, XXXII, p. 273, 1921.
Montandon; determination in U. S. National Museum.

Size. Length from tip of beak to tip of abdomen, 32 mm. to 38 mm.; caudal filaments, 22 mm to 27 mm. long.

Color. From light to very dark fuscous; top of abdomen orange and black; middle and hind legs of lighter forms banded.

Shape. Long and slender, prothorax long and slender; eyes very prominent and large; limbs all very slender and very long; the under side of prothorax with a single broad and deep sulcus, which distinguishes this species from any of our other forms (see fig. 6, pl. XLVIII).

Structural peculiarities. The eyes very prominent, transverse diameter greater than the interocular space; tylus longer than jugæ and as prominent as these parts, which are of medium development; antennæ with the lateral prolongation of penultimate segment not more than half the length of ultimate; prothorax slender, the anterior portion measured on the median dorsal line, twice the length of the posterior swollen part (the well-marked long transverse lateral grooves used as dividing line); scutellum somewhat elevated and slender and the length of the abdomen is to pronotum as 2¼ is to 1; respiratory filaments surpassing front margin of scutellum when brought forward; claspers of male genital bulb very distinct; subapical tooth greatly reduced (see fig. 1, pl. XLVI); all the limbs strikingly long and slender, especially the anterior femora (see fig. 1, pl. XLVIII); no apical tooth on anterior femur, the other tooth much nearer the apex than the base, the basal part being at least 1½ times as long as the part lying before the tooth; the coxa two-thirds as long as the femur.

The middle and hind legs long, the distal ends of hind femora surpassing the last abdominal suture and often nearly attaining caudal end of genital segment, while the middle femora frequently attain or surpass the caudal margin of penultimate abdominal segment; the distal ends of middle and hind legs almost attaining tip of respiratory filaments; the relative lengths of femora to tibiæ are about as 16 is to 19 for the middle leg and as 16 is to 22 for hind leg. The tarsi are small relatively, a little less than one-sixth as long as their tibiæ.

Notes. Described from the following series:

Male holotype, Colorado county, Texas, June 24, 1922; Mrs. Grace Wiley, collector.

Female allotype, Colorado county, Texas, June 24, 1922; Mrs. Grace Wiley, collector.

Paratypes as follows:

2 ♀♀ Raleigh, N. C., July 10, 1902; F. Sherman, jr., collector.
♂ Mound, La., November 6, 1918.
♀ Aberdeen, Miss.; Dr. Carl Drake.
3 ♀♀ and 1♂ Leland, Miss., September 16, 1921; C. J. Drake.
♀ Creve Coeur Lake, Mo., May 15, 1911; J. F. Abbott.
♂ Dime Box, Tex., July 20, 1911; C. T. Atkinson, collector.
17 ♂♂ and 22 ♀♀ Gainesville, Fla., June 19, 1918; Carl Drake.

Holotype and allotype in University of Kansas museum; paratypes in collection of Dr. Carl Drake, J. R. de la Torre Bueno, and the author.

This species has been named for Mr. J. R. de la Torre Bueno, who pointed out its structural characters in 1905.* It has also been named by some workers *R. fusca* P. B., and by at least one *R. nigra* H. S. It is clearly impossible for it to be either. The error of considering it *R. fusca* P. B. has been due to the inadequate description of *R. fusca* P. B. and to the fact that the original text with illustration has not been accessible to many, if any, American students of this group. By taking Palisot de Beauvois' figure of his *R. fusca* and comparing it with the species above described, it will be seen at once that the species are not the same. The long, slender limbs, the great eyes, the long thorax, the relative position of the tooth on the front femur, and the relation in length between femora and tibiæ of the legs, preclude the possibility that Palisot's artist had *R. buenoi*, sp. new, before him. The front legs of *R. fusca* P. B. are stout, not exceedingly slender. The median tooth of front femur is nearer the middle than in *R. buenoi*, sp. new. The anterior part of prothorax is less than twice the swollen part. The middle femora and tibiæ are nearly the same length as they are in *R. americana* Montd., for instance, and not considerably different in length as in *R. buenoi*. The hind femora are considerably shorter relative to the abdomen in *R. fusca* P. B. The tarsus of *R. fusca* P. B. is larger, being one-fifth as long as its tibia and not one-sixth as in *R. buenoi* sp. new. In other words, its proportions fit another American species, but not *R. buenoi*.

This species is not *R. nigra* H. S., for *R. nigra* H. S. has uniformly short respiratory tube of three-fourths inch and measures

* See Can. Ento., vol. XXXVII, p. 188; 1905.

over all from tip of beak to end of filaments 2 to 2⅛ inches, while this species has a tube averaging a full inch and varies in size from 2⅛ to 2½ inches. The shape of the eyes as shown in Herrich-Schäffer's figure, is very different, and the size which he says is "not larger than *R. linearis*," would at once eliminate it, for in *R. buenoi* they are very large, but not so large as in *R. elongata*, specimens of which I have seen.

For illustration of this species, see figures 1 and 2, plate XLVI; fig. 12, plate XLVII; figure 1, plate XLVIII; and figure 5, plate XLIX. This species, as Bueno has written, is southern in distribution. Besides the localities above cited, I have seen it from Waycross, Ga., taken by J. C. Bradley, U. S. N. M.

Ranatra nigra Herrich-Schäffer.

Herrich-Schäffer, G. A. W., Wanzenartigen Insecten, IX, p. 32; 1853.
(= *Ranatra protensa* Montd. and all subsequent writers.)

Original description:

R. nigra m. tab. 290, fig. L, 2 = 2⅛". Nigra, tubis respiratoribus longitudinem dimidiam corporis parum superantibus. Grösse fast von *R. linearis*, schwarzer, die Augen nicht grösser aber seitlich mehr vortretend, der Scheitel daher breiter. Bau des Thorax und Längenverhältnisse der Beine wie bei *R. elongata*. Aus Amerika.

In addition to the above, and in the discussion relative to the genus *Ranatra* and the species *R. elongata*, *R. filiformis*, *R. linearis*, *macrophthalma* and *R. nigra*, he gives notes of comparison which throw further light upon his species. He says *R. elongata* has the longest respiratory tube (1¾ inches) and *R. nigra* has the shortest (¾ inch). The color is darkest in *R. nigra*, "die Augen sind am grössten bei *macrophthalma*, am kleinsten bei *linearis*, am rundesten bei letzerer, am meisten in die Quere gezogen bei *nigra*." His statement of length, 2 to 2⅛ inches from tip of beak to tip of tube with "Athmungsröhren nicht viel über halb so lang als der Körper," indicate that he had a series of the insects.

Notes. The only species of our country which agrees in size and uniformly short length of respiratory tube with the description of *R. nigra* is the insect we know under the name *R. protensa* Montd. Doctor Montandon had before him a single large, fairly short-limbed female, which is his type deposited in the United States National Museum. This ♀ was collected by Wm. H. Ashmead on Long Island. The respiratory tube is shorter than the abdomen. The legs extended would surely reach the tip of the respiratory tube.

Ranatra nigra is quite common over our country everywhere I have collected. It is most unfortunate that it was described from

blackened specimens, for indeed it is our lightest-colored species, being of a yellowish color with a trace of green throughout. This species has very prominent mesocoxæ and metacoxæ, which are angular, having a slight tubercle on the inner side. The breast, or prothorax in front of the mesocoxal elevations, is constricted and small, making the coxal elevations very pronounced.

The United States National Museum possesses, besides the type, specimens from Virginia, West Virginia, Pennsylvania, Maryland, Arkansas and Florida.

I have before me a series of seventy-nine specimens from Doniphan county, Kansas, taken by Robert Guntert and W. J. Brown; ten from Douglas county, Kansas, and forty specimens taken by Mr. W. E. Hoffmann and myself from the following places in Minnesota: Lake Johanna, Phalen lake and Minnehaha creek, all near the twin cities. We have also taken it in other parts of the state. Careful study of ample material, well distributed, shows that by far the commonest size is, total length, two inches, with respiratory tube three-fourths inch! The length of hind femur relative to abdomen varies, sometimes attaining the front margin of the genital segment and sometimes falling somewhat short of this. The eyes are transverse and somewhat protuberant. The jugæ fit closely against the tylus. The lateral prolongation of the penultimate segment of the antennæ is less than half the ultimate. The front femora are very slender and coxæ long. On page 156 of the University of Kansas Science Bulletin, vol. XI, where I give an English translation of Doctor Montandon's description in French of *R. protensa*, I should have written, "Anterior femora quite slender, but scarcely a fifth longer than their coxæ," instead of "as long as"—a careless error.

Ranatra annulipes Stal.

Stal, Öf. Vet. Akad. Förh., XI, p 241, 1854

Original description:

R. annulipes: Flavotestacea; hemelytris fuscescente testaceis; pedibus obsolete fuscoannulatis; spiraculis nigrofuscis. Long. 30, lat. 3¾ millim.—Brasilia.

In 1861, under the title "Genera Nepidarum synoptice desposita," in his "Nova methodus familias quasdam Hemipterorum disponendi," "Ofversigt af Kongl. Vetenshaps akademiens förhandlingar, Arg. 18, 1861, No. 4, he gives a more satisfactory description:

Ranatra annulipes. Stal. Nepidæ, 1861, p. 9.

R. annulipes. Pallide testaceo-grisea, pedibus obsolete fusco variis; abdomine dorso sanguineo-fusco, lateribus griseo-flavescentibus, stigmatibus nigris,

dorso pellucentibus; fronte convexiuscula; alis levissime infuscatis; prosterno bisulcato; femoribus anticis pone medium intus unidentatis, extus ibidem at prope apicem inermibus, intermediis posticis subbrevioribus, his ad medium segmenti ultimi abdominis porrigendis; aidothecæ appendicibus corpori æquilongis. Long. 30 millim. Brasilea (Mus. Hohn.).

Ranatra annulipes Stal. Of. Vet. Ak. Förh., 1854, p. 241-1. Præcedentibus duabus affinis et cum iisdem divisionem forma metasterni distinctissimam, Americam habitantem formans. Secundum formam metasterni in divisiones quattuor distinctas, determinationem specierum facilitantes dividi potest *Ranatra* genus."

Doctor Montandon (Bul. Soc. Sci. Bucharest, XVIII, 1910), who has examined Guérin's type of *R. fabricii* (1857) pronounces it to be the same as *R. annulipes* Stal, 1854. Sagra's Historia fisica, politica y natural de la Isla de Cuba, volume VII (1857) is not available to many of our workers; therefore, Guerin-Méneville's description of *R. fabricii* follows:

Ranatra fusca tubo respiratorio corpore paulo longiore; pedibus anterioribus nigro-fuscis; corpore infra obscure ferrugineo. Larg. 35, Anch. 3 millim.

Notes. This species is distinguished from all our species by having the connexivum of the genital segment enlarged and extended ventrally at the caudal end embracing the distal portion of the genital operculum (see fig. 11, pl. XLV). I have never seen specimens of this species from the United States and Prof. H. G. Barber informs me that his record from Texas was on a mistaken identification. Mr. W. L. McAtee says the species appears to be common in Cuba.

Ranatra fusca Palisot Beauvois.

Palisot de Beauvois, A. M. F. J., Ins. Rec. Afr. Am., p. 235; 1805.
(= *R. Americana* Montd., 1910, and subsequent writers.)

Original description:

Ranatre brune. Brune-verdâtre; soies un peu plus courtes que le corps; ailes brunes-rougeâtres. (Fig. 1.)

Ranatra fusca. Viridi-fusca; setis corpore brevioribus; alis fusco-rubellis. (Fig. 1.) États-Unis d'Amérique.

Obs. Cette espèce diffère de celle d'Europe par sa couleur plus pâle, par les soies qui terminent l'abdomen, plus courtes que le corps, par les ailes et le dessus de l'abdomen d'un brun rougeâtre.

Notes. A photographic reproduction of Palisot's figure (natural size) is given on plate XLIX, figure 1. On a previous page I have stated the evidence to show that Palisot's illustration is natural size. Size alone shows that Palisot's species is not the same as *R. kirkaldyi* Bueno. It also eliminated *R. nigra* H. S. (= *R. protensa* Montd.). The short legs and stout front femora eliminate *R. fusca*

Bueno. Even after making due allowances for "artist's license," it is not conceivable that the careful artist illustrating Palisot's species could have been looking upon *R. fusca* Bueno. The eyes of *R. fusca* Bueno are strikingly large, the anterior femora very slender, and the middle and hind tibiæ much larger in proportion to their femora than in *Ranatra fusca* P. B.

Doctor Montandon (Bul. Soc. Sci. Bucharest, XIX, 1910), who also has examined Palisot's figure, says in effect regarding it: ". . . When one considers only the essential details for the characteristics of a form, such as the proportional length of the legs and appendages, one recognizes without difficulty its short and very robust anterior femora, its very little developed posterior legs, and its appendages shorter than the abdomen . . ."

He was led into error by assuming the figure to be a great enlargement of Bueno's *R. kirkaldyi,* which cannot be true according to the facts elsewhere presented in this paper. Doctor Montandon says that his *R. americana* is readily distinguished by the shape of the prothorax, and indeed he is correct. The posterior enlarged part is plump and then narrows to a slender neck, then widens again in front. Any student with much experience with American *Ranatra* will recognize this characteristic at once (see Palisot's figure reproduced on plate XLIX, figure 1). Compare it with the photographs of our other species. Palisot's insect was broad and large; our only species comparable to it is *R. americana,* which is as large, sometimes a trifle larger. The anterior portion of prothorax is about one and one-half times the swollen posterior portion; so it is in *R. americana* Montd. (in *R. fusca* Bueno [= *R. buenoi,* sp. new] the anterior part is about twice the posterior part). The legs are short; so with *R. americana* Montd. The large ratio of length of tarsus to the tibia, 1 to 5+ (in *R. fusca* Bueno, 1 to 6+), shows similarity; also the hind tibia is a little longer than the femur, but not as much as in *R. fusca* Bueno. The broad anterior femora agree with *R. americana,* but the apical tooth is not shown. This, however, is a character which all students of this group realize could be overlooked readily. Sometimes the space in front of the tooth is filled with debris, obscuring the tooth; sometimes the tooth itself is much reduced. Doctor Montandon has a specimen from Philadelphia and another from Texas which lack the tooth and which he designates under the name *R. americana* var. *edentula.* In many of the specimens the tooth, therefore, is not marked and must have been overlooked by Palisot's artist. The caudal filaments are comparatively

short in the figure; so they are in many specimens of *R. americana.* I possess examples with even shorter filaments. On the whole, I should say the average is longer, but not as long relatively as in *R. buenoi,* sp. new (= *R. fusca* Bueno), or in *R. drakei,* sp. new, or in *R. australis,* sp. new. It is most robust and, on the whole, our largest species. I have collected it in New York, Minnesota and Kansas in numbers, and have seen specimens from various other states.

Ranatra brevicollis Montandon.

Montandon, A. L., Bul. Soc. Sci. Bucharest, XVIII, p. 184; 1910.

Original description:

Ranatra brevicollis nov. sp. C'est bien à regret que je décris cette nouvelle forme sur un exemplaire malheureusement unique, assez peu dissemblable, au premiér aspect de *R. quadridentata* Stal, mais ses caractères spécifiques ne premettent pas de la confondre avec les autres espèces *fusca* ou *quadridentata* dont elle diffère par ses fémures antérieurs très légèrement sinués vers leur extrémité. Elle a aussi une seule dent devant la sinuosité médiane de fémur. Un peu plus trapue, de forme moins allongée que *R. fusca* Pall. de B., ce qui pourrait la rapprocher de *R. quadridentata* Stal, elle se sépare aussi franchement de cette dernière par la forme du pronotum beaucoup plus court. En effet l'insecte a 34 mill. de longueur, sur lesquels la tête et le pronotum n'ont que 10 mill Les appendices de 22 mill. sont sensiblement plus courts que l'abdomen. Les fémurs intermediaires et postérieurs courts, repliés en avant dépassent à peine la tête.

Le pronotum très robuste presque trois fois plus court que l'abdomen, assez fortement dilaté en avant et très fortement élargi en arrière, ne permet pas de la confondre avec *R. kirkaldyi* T. B. Il est en outre marqué de deux sillons longitudinaux un peu obliques sus les cotés, derrière la dilatation antérieure, n'atteignant pas en avrière les sillons transversaux qui limitent en avant la partie postérieure dilatée du pronotum. Cette dernière marquée d'une carène longitudinale médiane évanescente en arrière, mieux accentuée en avant où elle traverse les sillons transversaux qui limitent la partie postérieure dilatée.

Les pattes pas très grêles, un peu plus courtes proportionnellement que celles de *R. quadridentata* Stal; fémurs rougeâtres, marqués d' anneaux pâles, larges, peu visibles.

Metasternum en plaque, terminé au milieu en arrière par un prolongement rétréci entre les hanches postérieures, paraissant plus relevé que chez *R. fusca* P. de B. et *R. quadridentata* Stal, mais moins cependant que chez *R. fabricii* Guér. = *annulipes* Stal.

Cette espèce se distingue encore des trois autres formes connues de l'Amérique du Nord par l'opercule génital ♀ dépassant un peu sous la base des appendices. Le segment ventral qui précède l'opercule génital presque droit sur son faite longitudinal très peu convexe avant l'extrémité.

L'espace interoculaire convexe entre les yeux, mais sans trace de tubercule, à peine plus large qu'un œil. Les yeux très légèrement transversaux.

San Diego, Cal. Coll. Coquillett. U. S. N. M., Washington.

Notes. I have examined the type at the United States National Museum, the single example from which Doctor Montandon drew his description. It is a female. There is also a male with same data, that probably was taken with the type, and in addition there are two females from Eldorado county, California. One of them bears this note: "Fife of this insects were seen feeding on one grasshopper which got into the water." Another specimen, a female, from Lindsey, Cal., taken by C. Pemberton, is also in the National Museum. I have in my collection some specimens from Laguna Beach, Cal., taken by C. T. Dodds. To me the most striking character of *Ranatra brevicollis* is the apparently truncate head; the head does not appear broader than anterior part of pronotum, which is thick and short. The anterior lateral prolongation of the penultimate segment of the antenna is short, but little more than half the ultimate.

The salient characters, as assigned to this species by Doctor Montandon, are: Body thick-set, pronotum short, appendages shorter than abdomen, the legs not very slender, a little shorter proportionally than those of *R. quadridentata* Stal; metasternal plate with a middle prolongation between the posterior coxæ, more elevated than in *R. fusca* P. B. (= *R. buenoi*, sp. new), and *R. quadridentata* Stal, but less, however, than in *R. fabricii* Guér. = *annulipes* Stal. He says also that the genital opercule extends a little under the base of the appendages and the ventral segment which precedes the genital opercule almost straight on its longitudinal summit, very little convex before the extremity. I find, however, that the male operculum does not extend under the base of the appendages.

All of the insects of this species which I have seen came from California. (See fig. 2, pl. XLVIII; fig. 3, pl. XLV; fig. 14, pl. XLVII; fig. 3, pl. L.)

Ranatra australis, sp. new.

Size. Smallest specimen in our series measures 32 mm. from tip of beak to tip of abdomen with a respiratory tube 27 mm. long. The largest specimen is 37 mm. long with a tube 30 mm. long.

Shape. On the whole a slender species with a long prothorax and long hind femora.

Structural peculiarities. Eyes normal; jugæ very prominent, more elevated than tylus, a characteristic that distinguishes this species; antennæ with lateral prolongation of penultimate segment nearly as long as ultimate. Prothorax slender, sides fairly straight, the anterior portion measured on the median dorsal line two more or less times the posterior swollen part. Respiratory filaments quite long, a little less than length of the insect. The clasper

of the male genital capsule with the anteapical prolongation truncate and short and well separated from the apical. (See fig. 3, pl. XLVI.) Front femora broad without apical tooth. Hind femora surpassing the middle of the penultimate segment of the body and the hind tarsus reduced to one-sixth of its tibia. (See fig. 4, pl. XLVIII; fig. 1, pl. L; and fig. 15, pl. XLVII.)

Notes. Described from the following:

Holotype: Male, Colorado county, Texas, June 24, 1922; Mrs. Grace Wiley.

Allotype: Female, Colorado county, Texas, June 23, 1922; Mrs. Grace Wiley.

Paratypes: Five males and four females, Colorado county, Texas, June 23 and June 24, 1922; Mrs. Grace Wiley.

Nine males and three females, Gainesville, Fla., June, 1918; C. J. Drake.
One female, New Orleans, La., June, 1915.
One male, McComb, Miss., July 27, 1921.
One female, Fayette, Miss., July 23, 1921; C. J. Drake.
One male, Mound, La.,; J. C. Bradley (teneral specimen).
One male, Calyell, La., June 16, 1917; H. H. Knight.
One male, Kissimmee Lake, Florida; A. N. Resse.

Total of twenty-nine specimens from Texas, Florida, Mississippi and Louisiana. The last specimen, belonging to the U. S. National Museum, was labeled *R. fusca* by Doctor Montandon in 1909, and bears the following interesting note: "Alligator flea, water dog, said to bite or sting severely. Swamp east of Lake Kissimmee, Osceola county."

The holotype and allotype and two paratypes are in the University of Kansas collection; paratypes are also in the collection of Dr. C. J. Drake, Ames, Iowa; the United States National Museum, Washington, D. C.; J. R. de la Torre Bueno, and the collections of Mrs. Grace Wiley and of the author.

This species is smaller, slenderer and longer limbed than *R. fusca* (=*R. americana* Montd.). It differs also in the following particulars:

1. The jugæ more prominent than tylus—not true in *R. fusca* P. B.
2. The eyes are smaller than in *R. fusca* P. B.
3. The pronotum is longer; the anterior part two more or less, times the posterior part, whereas in *R. fusca* P. B. it is 1½ to 1½+.
4. The sides of prothorax more nearly parallel and posterior swollen part not so swollen.
5. The hind margin of pronotum roundly and broadly emarginate, whereas in *R. fusca* P. B. (=*R. americana* Montd.) the emargination is deeper and narrower.
6. The two depressions on the scutellum are deep and pitlike, while in *R. fusca* P. B. they are shallow and broad.

7. The hind femora longer, surpassing the middle of the penultimate body segment, often almost attaining its caudal margin. Femora not so developed in *R. fusca.*
8. Hind tarus of *R. australis* one-sixth or less of the tibia; one-fifth or less in *R. fusca* P. B.
9. Metaxyphus usually longer.
10. The female operculum angulate on its ventral line, while it slopes gradually and is longer in *R. fusca* P. B.
11. The respiratory filaments are relatively longer in *R. australis* sp. new, than in *R. fusca* P. B.
12. The front femora lack the apical tooth; *R. fusca* P. B. has one more or less marked.

Ranatra drakei, sp. new.

Size. Length from tip of beak to tip of abdomen 35 mm. to 46 mm.; in addition to this, the respiratory filaments are from 28 mm. to 44 mm. long.

Color. All the specimens in the series studied are yellowish brown with legs and tegmena overcast with an orange tinge.

Shape. A long, slender species with prominent eyes; long, slender prothorax; hind femora surpassing the middle of the last abdominal segment, and a very long respiratory tube.

Structural peculiarities. The eyes very prominent, transverse diameter greater than interocular space; jugæ prominent and divergent; antennæ with lateral prolongation of penultimate segment a little more than half the length of the ultimate segment; prothorax slender, the anterior portion measured on the median dorsal line 2½ times length of the posterior swollen part. The length of abdomen is to length of pronotum as 2¼ is to 1; the respiratory filaments long, as long as entire body in many of the specimens, greatly surpassing the limbs. The claspers of the male are shown on plate XLVI, figure 11. The limbs are long and slender; front femora slender, median tooth considerably nearer apex than base; distal tooth well marked and located at some distance away from the tibial joint, this distance being about one-fourth the length of that part of femur lying in front of the median tooth (see fig. 3, pl. XLVIII); middle and hind femora long; distal end of hind femora attaining, or nearly attaining, the caudal margin of the penultimate abdominal segment; the ratio between femora and tibia not quite but nearly as great as in *R. buenoi*, sp. new. See plate L, photograph 4 of paratype specimen.)

Notes. Described from eleven specimens, seven males and four females, taken át Gainesville, Fla., ten of them by Carl Drake, June, 1918, and one specimen taken March 18, 1915, collector unknown; holotype in collection of Carl Drake, allotype in University of Kansas collection, paratypes in the above collections and in that of the author.

This species has the general appearance of *R. buenoi*, due to the large eyes and elongate, slender body. It differs from that species, however, in the front femur possessing a well-defined apical tooth;

in more prominent jugæ; in differently formed antennæ; in its longer thorax; in the respiratory filaments greatly surpassing the limbs when extended backwards, and in the differently formed claspers of the genital capsule of the male. It cannot be confused with any other of our species.

Ranatra quadridentata Stal.

Stal, Öfversigt af Kongl Vetenskaps akademiens förhandlingar, Arg. 18, 1861, No. 4, p. 204.

Original description:

Grisea, pedibus immaculatis; abdominis dorso sanguineo; oculis modice prominulis; thorace antice leviter ampliato, subtus bisulcato; alis levissime infuscatis; femoribus anticis subtus pone medium et prope apicem, licet hic obsolete, bidentatis, intermedus posticis vix aequilongis, his basim segmenti penultimi abdominis vix superantibus; metasterno ut in præcedente. Long. 33 to 36 millim. Mexico. (Mus. Hohn.) Præcedenti affinis.

The "preceding" is *R. unidentata,* from Rio Janeiro, and concerning its metasternum he says,

"metasterno retrorsum fere ad apicem coxarum posticarum producto, segmentum ventrale primum tegente, uti videtur postice trilobato, lobis continuis, elongatis, medio convexo, lateralibus depressis, subarcuatis."

Notes. Van Duzee's catalogue completely submerges United States records of this species under *R. americana* Montd.* This is not justified, because Doctor Snow in his list (Trans. Kans. Acad. Sci., vol. XX, pt. 1, p. 153; 1906) was not writing about the insect that Doctor Montandon described as *R. americana.* I have before me Doctor Snow's insect from San Bernardino Ranch. Cochise county, Arizona, the same thing from Mexico, and a series from Texas. These insects agree splendidly with Doctor Montandon's comparative notes on Stal's species, cotypes of which he has studied carefully.

When Doctor Montandon described his *R. americana* (Bul. Soc. Sci. Bucharest, XIX, p. 65, 1910) he gave some remarkably clear notes of comparison between his species and Stal's *R. quadridentata.* The latter is not so robust, the eyes smaller, not so transverse, the interocular space not so convex; checks not so elongate, but not applied so closely against the tylus, which is shorter, making the head before the eyes appear shorter. The median construction of the pronotum is not nearly so marked and the anterior part more cylindrical. I may add that the anterior part of the prothorax is longer proportionally, the legs are longer and metaxyphus longer.

---

* Van Duzee's catalogue, *quadrinotato.* Doctor F. H. Snow published a list of the insects taken by him in Arizona, and listed *R. quadridentata* Stal as one of them.

SUMMARY.

The Nepidæ of North America north of Mexico now include a total of eleven species and two varieties, distributed as follows: one *Nepa*, two *Curicta*, and eight *Ranatra* species with two varieties. This count omits *R. annulipes* Stal, which probably does not occur in our range. The naming of our two commonest and widespread species, under the two oldest names given, is as conclusively shown as can be done without authentic types. We have decided that our large, robust, short-limbed form, with broad anterior femora, is *R. fusca* P. B., and that our slender-limbed form, with uniformly short respiratory filaments, is *R. nigra* H. S. This, most unfortunately, reduces to synonymy *R. americana* Montd. and *R. protensa* Mondt., names by which these species have been well known to us for the past ten years. The antennæ and genital claspers of the males have been of value—very striking and satisfactory characters in most of the species. The genital capsules themselves are of little value systematically in most of the *Ranatra*. The intromittent organ of the male has a more or less definite and characteristic shape at its tip (compare figures 6-I and 8-I, plate XLVI). Care has been taken to examine material from various localities in order to fix the limits of variation of these characters.

PLATE XLIV.

FIG. 1. Egg of *Ranatra fusca* P. B. (= *R. americana* Montd.) dissected from a water-soaked dead cat-tail blade.

FIG. 2. Diagrammatic drawing of *Ranatra*. *A*, apical tooth of front femur. *M*, median tooth of front femur. *C*, front coxa. *G*, prothoracic transverse grooves which separate the "anterior part of the pronotum" from the "swollen posterior part." *S*, scutellum.

FIGS. 3 AND 5. Stridulating device of *Ranatra*. Figure 5 shows ventral view of head and a portion of prothorax. The rubbing of the roughened patch (*A*) on the base of the coxa (*C*) against the file (*B*) on the inside edge of the anterior lateral margin of the prothorax (*P*) produces the chirping or squeaky noise. *D*, antennæ. Figure 3 gives an enlarged lateral view of base of coxa and anterior lateral margin of prothorax cleared so that the file shows through. Lettering same in both figures.

FIG. 4. *Ranatra* eggs in situ in soft, decaying cat-tail leaf, a portion of which has been removed to expose the eggs.

FIG. 6. Genus *Curicta*. Note that it is intermediate in shape between *Ranatra* and *Nepa*. Until the appearance of this bulletin only a single specimen was recorded from the United States.

FIG. 7. Egg of *Curicta drakei*, sp. new, dissected from the tissues of a decaying plant stem, where only the crown of fifteen filaments was exposed. Drawing made from material secured by Mrs. Grace Wiley in her life history notes on this species.

FIG. 8. Egg of *Nepa apiculata* Uhl. Note the eleven filaments which remain exposed above the surface of the plant in which the eggs are inserted.

FIG. 9. Genus *Nepa*. Represented in the United States by a single species, *Nepa apiculata* Uhl. This species varies considerably in size, but no constant structural detail has been found to indicate that the variants are not conspecific.

PLATE XLIV.

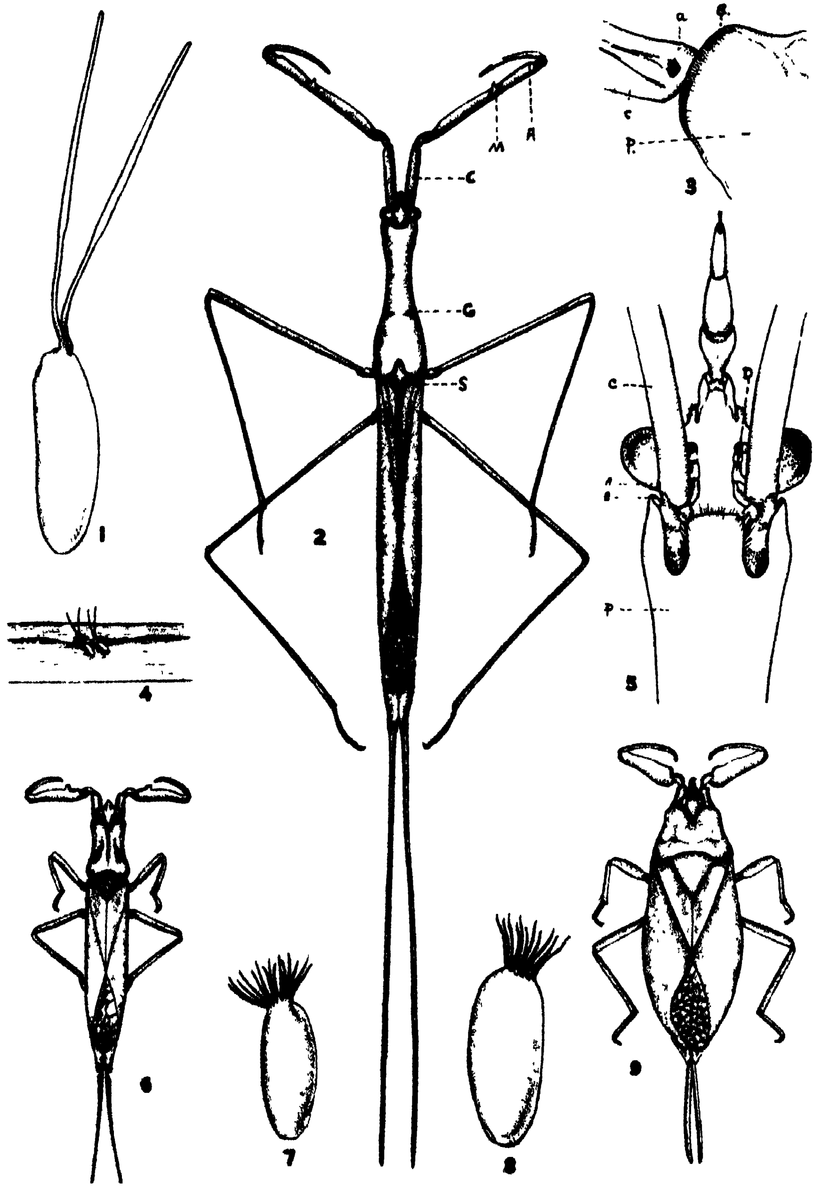


PLATE XLV.

FIG. 1. Clasper of male of *R. elongata* Fab., determined by Doctor Montandon. *S*, subapical tooth.

FIG. 2. Genital capsule of male of *R. elongata* Fab., determined by Doctor Montandon. Compare figures 1 and 2 with figures 3 and 4. Note the differences in shape of claspers, their relative lengths as shown in figures 2 and 4. The intromittent organ, *I*, is also often characteristic of a species, but not always, and subject to some variation. The capsule itself in *Ranatra* is of little value.

FIGS. 3 AND 4. Clasper and capsule of male *R. brevicollis* Montd. from California.

FIG. 5. Inside view of left clasper of *Curicta drakei*, sp. new. Compare with figure 8, *C. howardii* Montd. The shape of the clasper near the base is not the same in the two species.

FIG. 6. Male genital capsule of *C. drakei*, sp. new, viewed from right side.

FIG. 7. Male genital capsule of *C. howardii* Montd.

FIG. 8. Inside view of left clasper of *C. howardii* Montd.

FIG. 9. Ventral view of head of *Ranatra* to show the antennæ, which lie hidden. Sometimes they are covered with debris, which should be scraped away. It is often wise to relax the specimen and draw the antenna into a more exposed position. The front coxa also sometimes obscures the view and should be moved while specimen is relaxed.

FIG. 10. Lateral view of caudal end of abdomen and base of respiratory filaments of *Ranatra nigra* H. S. *C*, connexivum. *R*, respiratory filaments. *O*, operculum of genital segment, considered in this paper as last abdominal segment. *P*, considered in this paper as the penultimate abdominal segment.

FIG. 11. Lateral view of caudal end of abdomen and base of respiratory filaments of *Ranatra fabricii* Guér. from Cuba. Montandon says it is identical with *R. annulipes* Stal from Brazil.

FIG. 12. Dorsal view of head of *Ranatra*. *B*, beak. *J*, jugum. *T*, tylus.

PLATE XLV.

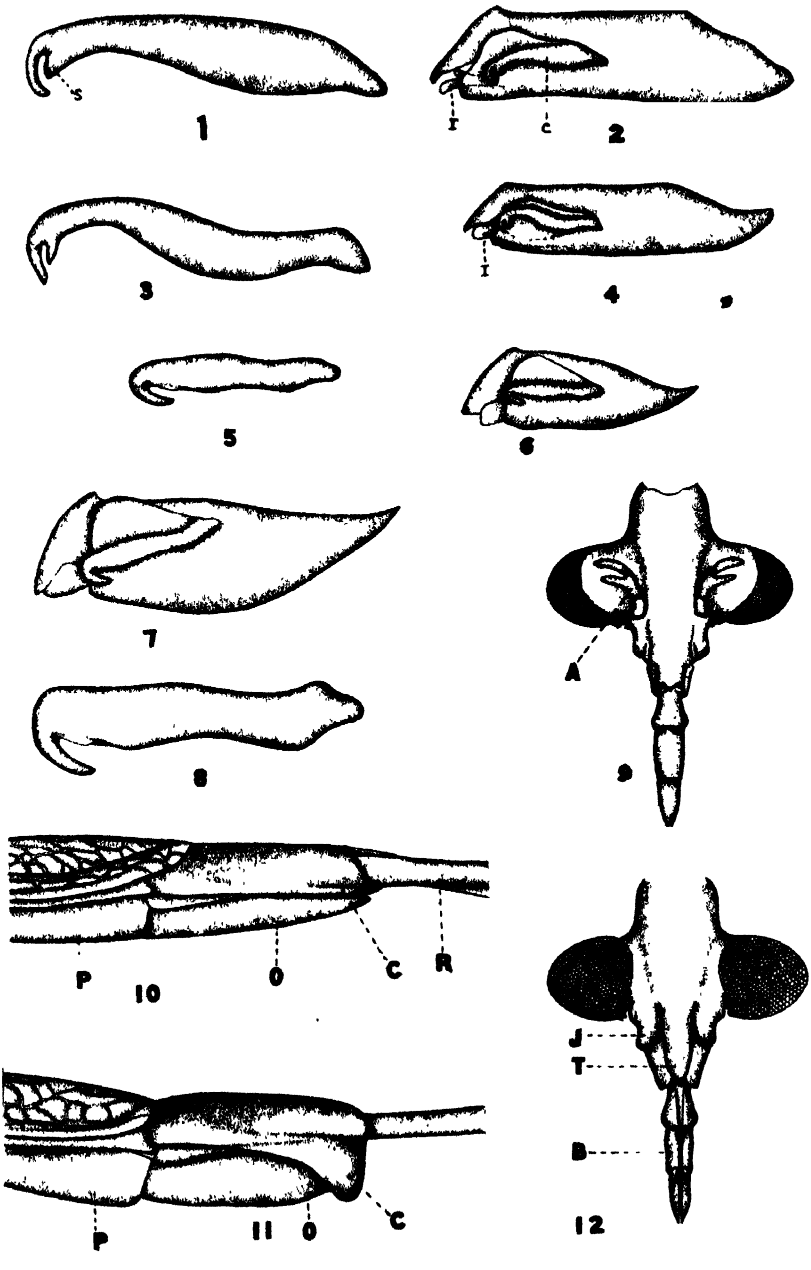


PLATE XLVI.

FIGS. 1 AND 2. Clasper and male genital capsule of *Ranatra buenoi*, sp. new. Note the reduced subapical tooth of the clasper and the spatulate form of the tip.

FIGS. 3 AND 4. *Ranatra australis*, sp. new. Note the truncate subapical tooth of the clasper and its distance from the apical one.

FIGS. 5 AND 6. *Ranatra kirkaldyi* Bueno. *S*, subapical tooth. *C*, clasper. *I*, intromittent organ. This species is clearly quite distinct in its relationship from the others. Note the shape of the intromittent organ and of the clasper.

FIGS. 7 AND 8. *Ranatra quadridentata* Stal. I am not able to find any constant differences between this and *R. fusca* P. B. (= *R. americana* Montd.) in respect to the male genitalia. The male of the latter species has, on the whole, a more slender clasper.

FIGS. 9 AND 10. *Ranatra brachyura* Horv., 1879, said to be same as *R. sordidula* Dohrn., 1860. From Japan. Confused by a student of this family with *R. protensa* Montd. and so labeled. Compare figures 9 and 13.

FIGS. 11 AND 12. *Ranatra drakei*, sp. new.

FIGS. 13 AND 14. *Ranatra nigra* H. S. (= *R. protensa* Montd.). The preceding species and this one have claspers which are broad in their middle parts, but the shape at the tip distinguishes them.

FIGS. 15 AND 16. *Ranatra linearis* Fab. From Europe. Berlese, in his Gli Insetti, p. 323, figures this species. Note that the difference between the clasper of this species and that of our American species is more apparent than the superficial appearance of the insects when side by side in the cabinet.

PLATE XLVI.

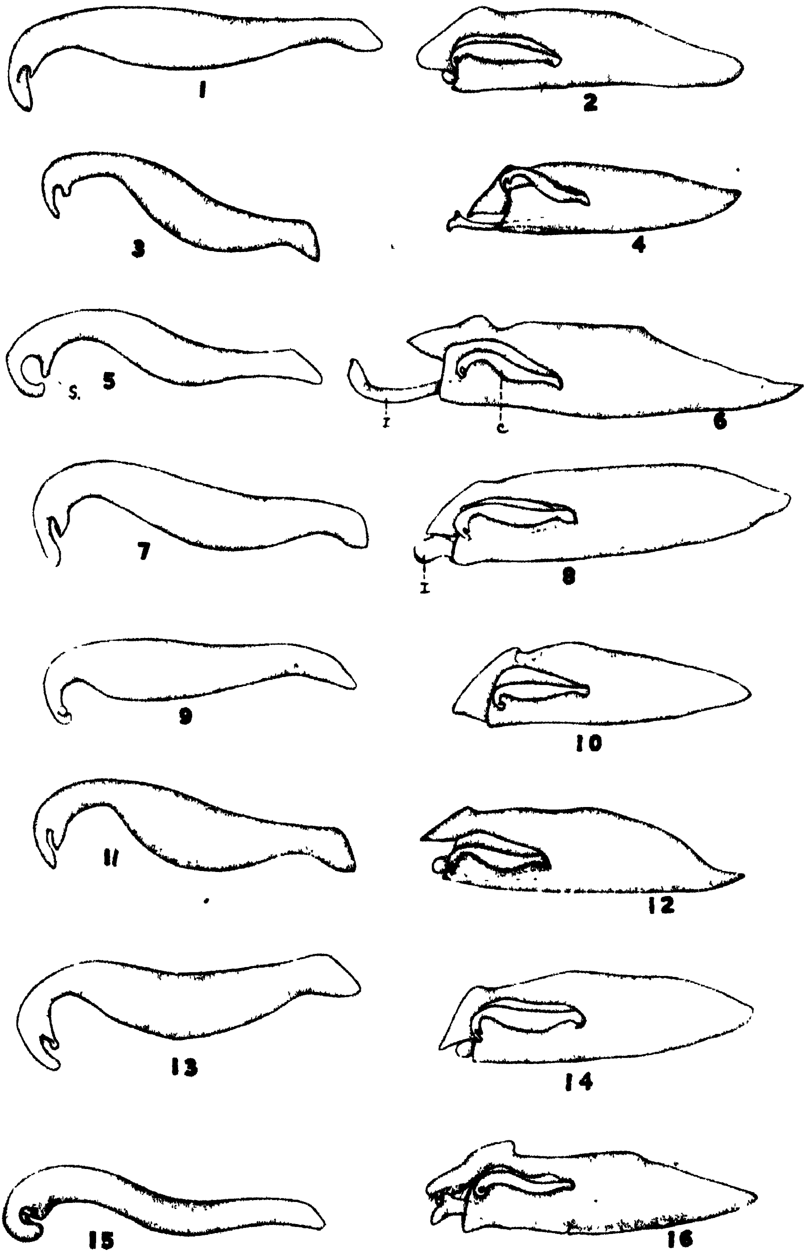


PLATE XLVII.

FIG 1. Ventral view of male genital capsule of *Nepa apiculata* Uhler. From North America.

FIG. 2. Lateral view of clasper of above. Compare with figure 4 of *N. cinerea* L. of Europe.

FIG. 3. Ventral view of male genital capsule of *Nepa cinerea* L.

FIG. 4. Clasper, lateral view of *Nepa cinerea* L.

FIG. 5. Antenna of *Nepa apiculata* Uhler. From New York.

FIG. 6. Antenna of *Nepa cinerea* L. From Europe *U*, ultimate antennal segment. *P*, penultimate antennal segment. *L*, lateral prolongation of penultimate segment. The splendid antennal and genital characters separating these two species of *Nepa* illustrate the taxonomic value of these hitherto unused structures in the Nepidæ. In the drawings which follow, do not attach significance to the basal segment, but to the last two segments.

FIG. 7. Antenna of *Curicta drakei*, sp. new.

FIG 8. Antenna of *Curicta howardii* Montd.

FIGS. 9 AND 11. Antennæ of *Ranatra kirkaldyi* Bueno. Sometimes the ultimate segment is fused with the preceding segment and sometimes entirely separate.

FIG. 10 Antenna of *Ranatra nigra* H. S. (= *R. protensa* Montd.).

FIG. 12. Antenna of *Ranatra buenoi*, sp. new.

FIG. 13. Antenna of *Ranatra drakei*, sp. new.

FIG. 14. Antenna of *Ranatra brevicollis* Montd.

FIG. 15. Antenna of *Ranatra australis*, sp. new.

FIG. 16. Antenna of *Ranatra quadridentata* Stal.

FIG. 17. Antenna of *Ranatra fusca* P. B. (= *R. americana* Montd.).

PLATE XLVII.

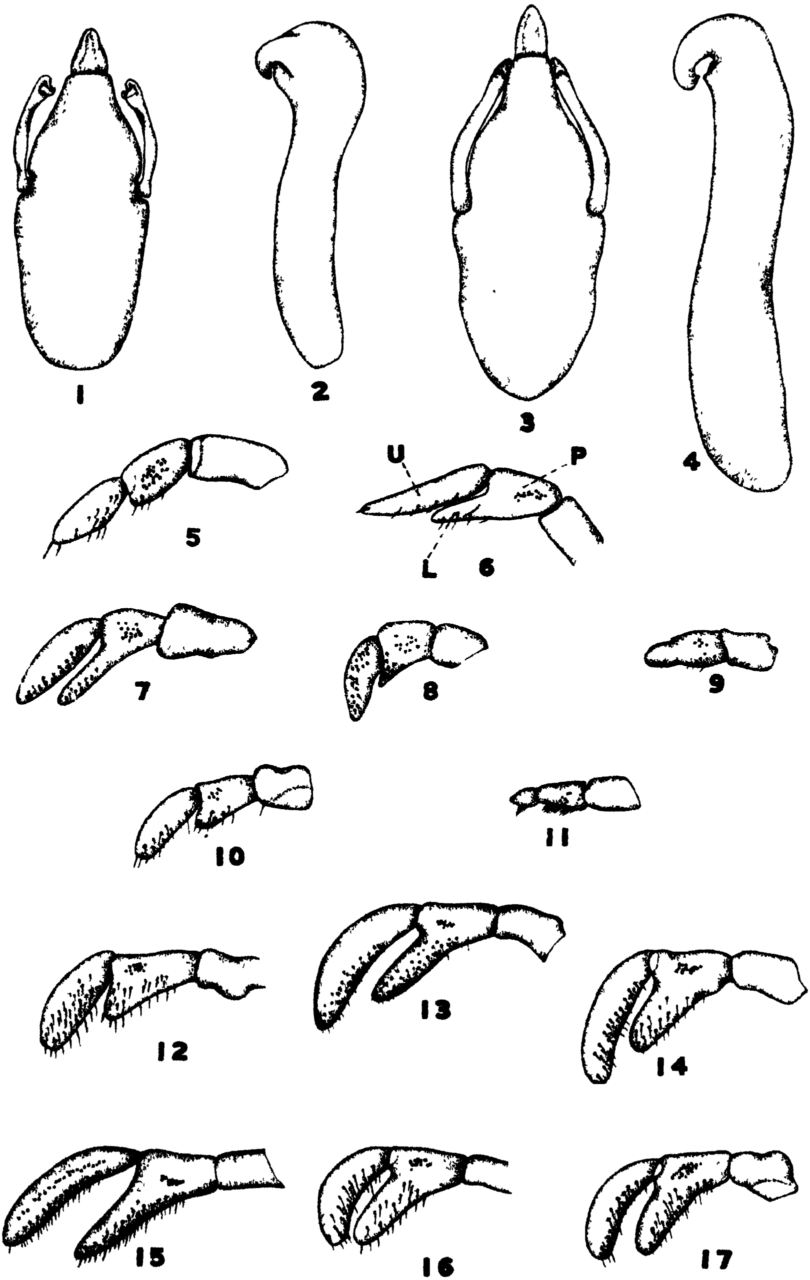


PLATE XLVIII.

FIG. 1. Front femur, tibia and tarsus of *Ranatra buenoi*, sp. new. Note its very slender form and the position of the median tooth.

FIG. 2. *Ranatra brevicollis* Montd. The median tooth is nearer the middle than in any of the others. The tibia is relatively longer.

FIG. 3. *Ranatra drakei*, sp. new. Note the slender form and the position of the apical tooth.

FIG. 4. *Ranatra australis*, sp. new. It lacks the apical tooth, and the anterior portion of the femur is not enlarged toward the distal end as in *R. fusca* P. B.

FIG. 5. *Ranatra fusca* P. B. (= R. *americana* Montd.). From Ithaca, N. Y.

FIG. 6. Ventral view of head and prothorax of *R. buenoi*, sp. new. To show the deep longitudinal trough. Compare with figure 10, which lacks it.

FIG. 7. *Ranatra kirkaldyi* Bueno. Note that the femur is not constricted in the region of the median tooth. Compare with *R. fusca* P. B., figure 5. This from Kansas.

FIG. 8. *Ranatra nigra* H. S. (= *R. protensa* Montd.)

FIG. 9. *Ranatra kirkaldyi* Bueno var. *hoffmanni* new. Apical tooth or marked sinuosity present. From Minnesota.

PLATE XLVIII.

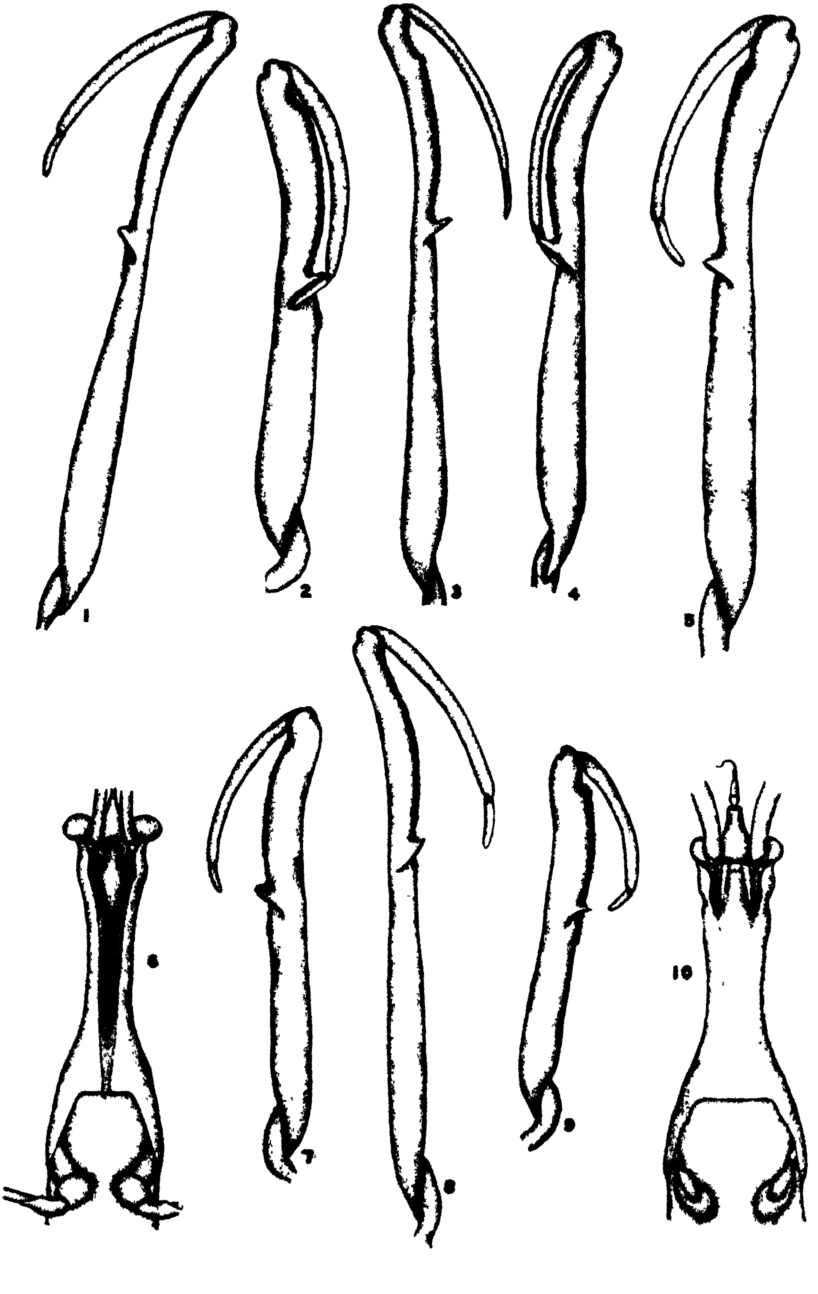


PLATE XLIX.

(All photographs natural size.)

PHOTO 1. Photograph of Palisot's figure of *Ranatra fusca*, reproduced exact size.

PHOTO 2. *Ranatra kirkaldyi* Bueno. Largest specimen in a long series. A female from Cherokee county, Kansas, determined by Mr. J. R. de la Torre Bueno. This is what Doctor Montandon has mistaken for *Ranatra fusca* P. B. Besides size, note shape of front femur. Not constricted as it is in figure 1.

PHOTO 3. *Ranatra fusca* P. B. (= R. *americana* Montd.) Note the general resemblance to original figure by Palisot (photo 1 above), the shape of the thorax, the broad anterior femora, the size of the insect, the reduced hind femora, etc. For other figures of this insect, see plate LI, photographs 3 and 7. Figure 7 is the only one to show the apical tooth of the front femur plainly. The writer has forms with the respiratory tube of various lengths. The shortest perfectly formed tube is shown on plate LI, figure 3.

PHOTO 4. *Ranatra kirkaldye* Bueno var. *hoffmanni*, var. new.

PHOTO 5. *Ranatra buenoi*, sp. new (= R. *fusca* Bueno). Compare with Palisot's *R. fusca* (photo 1). The relative proportions of the front femora, the length and shape of thorax, limbs and filaments. The long tibiæ and reduced tarsi. This photograph is of a paratype.

PLATE XLIX.

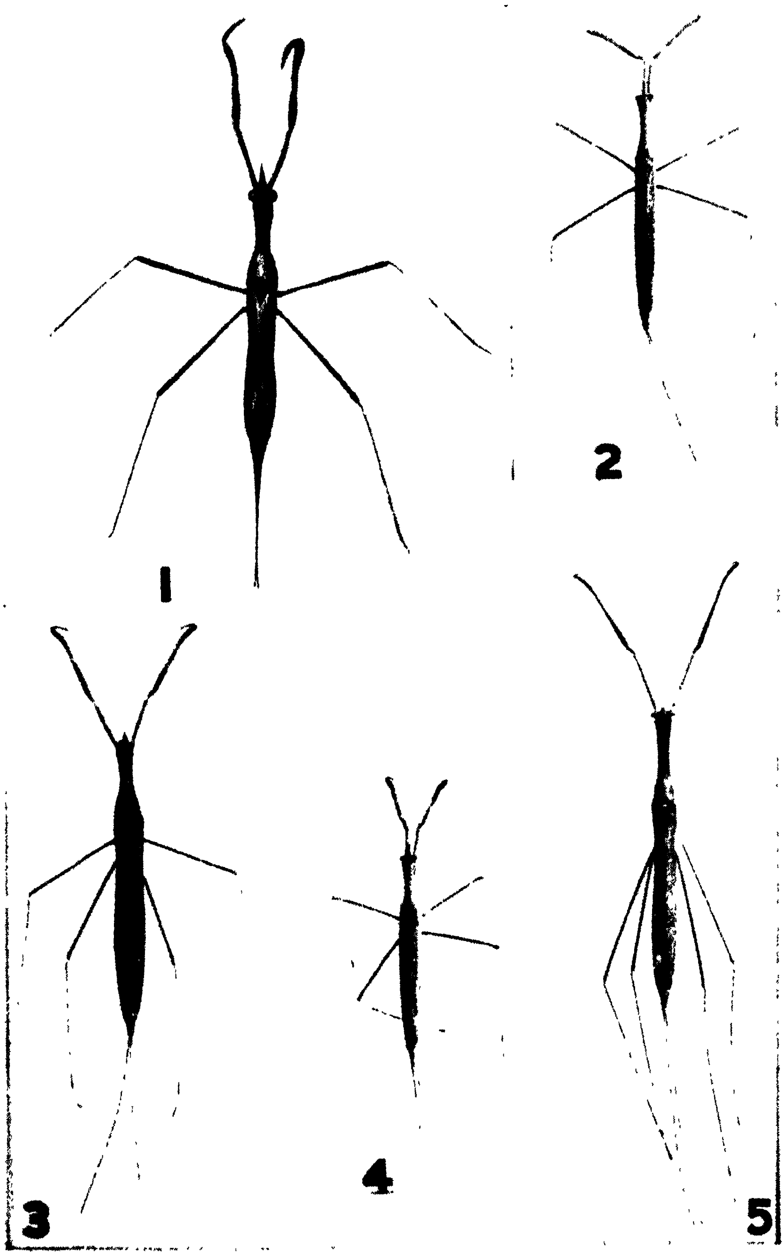


PLATE L.

(All photographs natural size.)

PHOTO 1. *Ranatra australis*, sp. new. Differs from *R. fusca* P. B. by shape of prothorax, longer respiratory tube, lack of apical tooth on front femora and by its elevated jugae, as well as marked differences in the genital claspers of the male. Southern in distribution. Photograph from paratype.

PHOTO 2. *Ranatra nigra* H. S. (= R. *protensa* Montd.) This insect in a long series fits the original description most remarkably, except for the color, which is of no consequence at all: "Size 2-2⅛ inches from beak to tip of filaments. Filaments ¾ inch long; limbs long and slender." Photo 5 is another specimen—the latter from Minnesota, the former from Kansas.

PHOTO 3. *Ranatra brevicollis* Montd. From California. Note the short broad thorax and its relation to the size of the head.

PHOTO 4. *Ranatra drakei*, sp. new. Slender front femora with apical tooth, large eyes, long thorax, long limbs, and very long respiratory filaments. (Photograph from paratype.)

PHOTO 5. *Ranatra nigra* H. S. (= R. *protensa* Montd.)

PLATE L

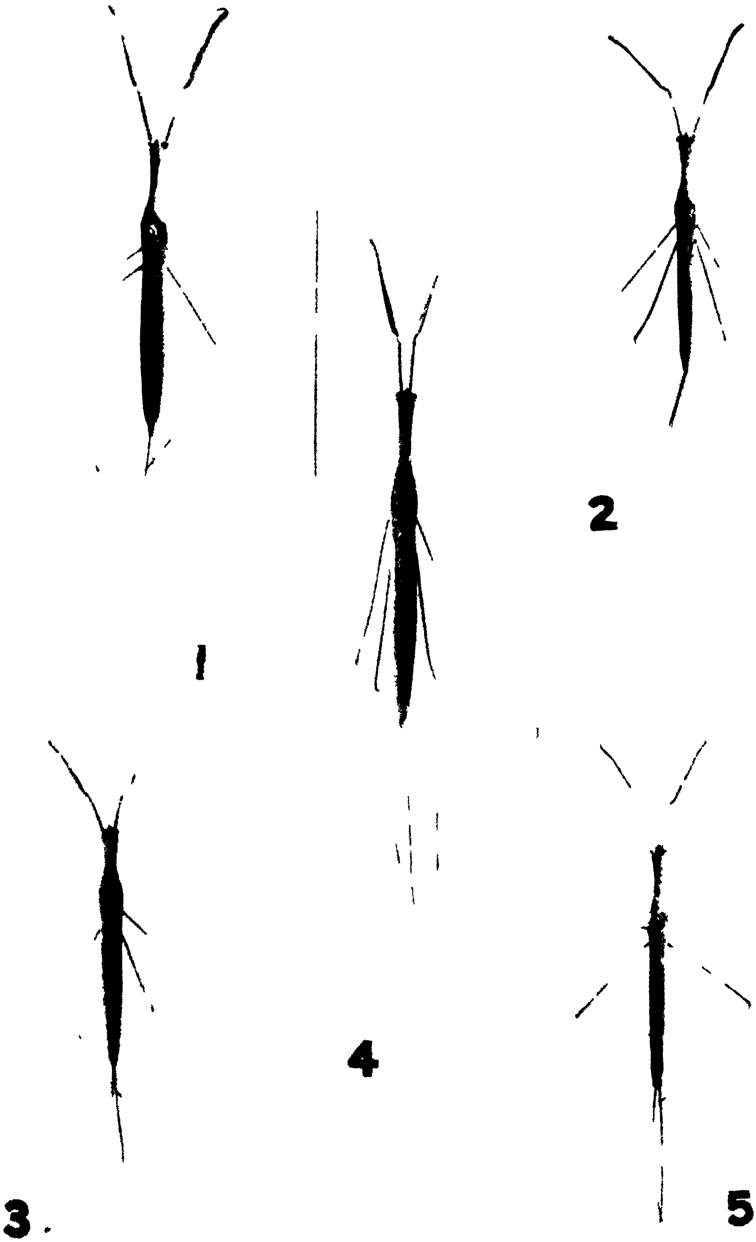


PLATE LI.

(All photographs natural size.)

PHOTO 1. *R. quadridentata* Stal. Small specimen taken by Doctor Snow in Arizona.

PHOTO 2. *Curicta howardii* Montd. Photograph from male belonging to Professor Barber. Compared with type at Washington by Doctor Drake.

PHOTO 3. *Ranatra fusca* P. B. Specimen from Minnesota with very short but perfectly formed respiratory filaments. The tips are normal.

PHOTO 4. *Curicta drakei*, sp. new. Male holotype.

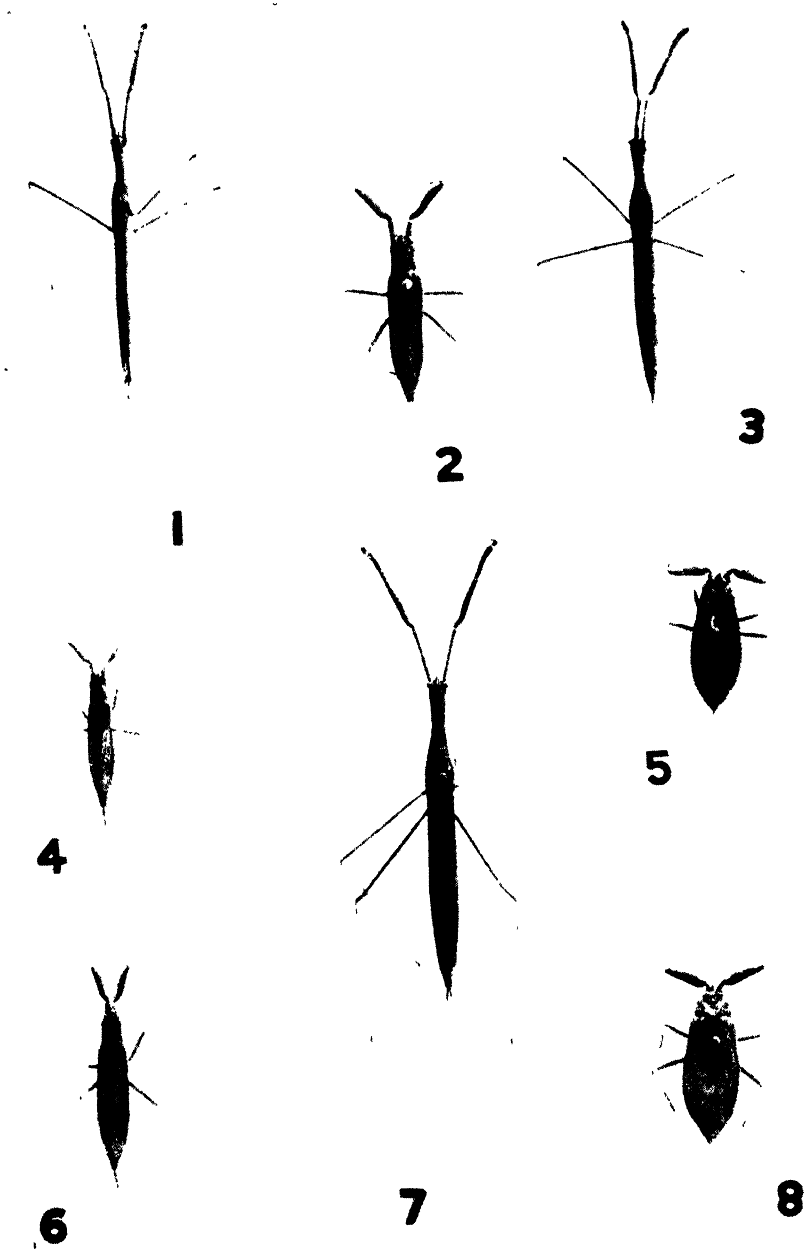
PHOTO 5. *Nepa cinerea* L. Male from Europe. Compare with *Nepa apiculata* Uhl. from Minnesota, photo 8, then note structural differences figured on plate XLVII.

PHOTO 6. *Curicta drakei*, sp. new. Female allotype.

PHOTO 7. *Ranatra fusca* P. B. Shows how long the respiratory filaments may be and how marked the apical tooth of front femur.

PHOTO 8. *Nepa apiculata* Uhl. Female from Minnesota.

PLATE LI.



THE

KANSAS UNIVERSITY

SCIENCE BULLETIN

VOL. XIV, No. 19—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 19.)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 19.

A Study of the Relation Between Function and Growth in Body Cells.

BY MONTROSE T. BURROWS, M D
The Department of Surgery, Washington University School of Medicine and the Barnard Free Skin and Cancer Hospital, St Louis, Mo

IN THE BODY, growth is a definitely regulated act, which during development takes place irregularly in one part and then in another. At maturity it ceases in most tissues, except as it is necessary to replace tissue or cells lost by injury, to meet the demands of an increased function of the whole or a part, and to take care of the general wear and tear. Function, on the other hand, such as heart-muscle contraction, is something that, once established, goes on continuously throughout the life of the individual.

Growth in the body is, therefore, that which has a maturity or has limits, while function (rhythmical heart-muscle contraction) has none.

These two processes are related in only one regard: for a given amount of work of contraction there is a constant size. A stimulus which induces an increase in work on the part of the heart induces also an increase in the size of the organ, while one which induces a decrease in work leads to atrophy. What is true for the heart is also true for muscles in general and for the kidneys, liver and other organs of the body. Growth of the muscle fibers and cells of these organs is proportional, therefore, to their rate of activity or to the rate of their metabolism. That the same is true in the embryo, even before differentiation and the development of function, has been clearly pointed out by Child.* [1] Child again points out that with each decrease in growth rate there is a decrease in the rate of metabolism,

* Superior figures refer to numbered paragraphs of the bibliography at the end of this article.

and that this metabolic rate increases markedly in lower forms after starvation or when they are regenerating lost parts.

The question of growth regulation may, therefore, be temporarily set aside for a study of the conditions which regulate metabolism in general in the cell. As the tables for growth clearly show, the metabolic rate in the organism is never constant (Child and Thompson).[2] In early embryonic life the increment is high, then it gradually decreases, with irregularities, up to the death of the individual. In the early stages of development the blastomeres are simple, expanding, growing cells. Later they differentiate and assume a functional state. That this differentiation and the development of function is brought about by the continuous changing environment effected by the growth and filling up of cells in the growing individual has been clearly indicated by many already well-known studies of experimental embryology.[3] What we have not known are (1) the nature of those conditions which bring about these changes, and (2) the importance of these changes for the life of the organism itself.

In later life we have learned to recognize the fact, however, that all tissues do not become actively functioning cells. A part of the mesenchyme changes to muscle and glands, while another part remains in what appears to be a more primitive state, such as the cells of the interstitial tissue, bone and cartilage. The same is true for epithelium. A part is used for covering and protection and another part becomes functioning glands. For the sake of simplicity, I shall call the cells which are active in the glands, in the muscle, etc., as functioning cells, in contradistinction to those of the connective tissue, bone, cartilage and the epithelial coverings, the nonfunctioning cells. This is not a strict use of the terms, but the latter resemble more closely in their behavior the undifferentiated cells of early life.

There was a time when it was thought that all life processes centered within the cell. At the present time there is some question whether this is true. The primary changes in early development appear to be a rapid swelling of the mass, a rapid inbibition of water and oxygen, a rapid elimination of CO_2, and a secondary splitting of the whole into cells. Cellular growth, division and differentiation are not primary activities, but apparently secondary to other more formative forces or stimuli. Life does not manifest itself the same throughout the life of the animal. In the beginning it is recognized chiefly by the rapid expansion of the whole, the rapid division of cells and the careful building of its various parts. This period of building is completed in man, as is well known, within ten days after

birth. Subsequent to this time no new organ or parts of organs are formed except the laying down of the nerve sheaths. All subsequent growth is merely the expansion of previously formed structures. It is like hypertrophy and hyperplasia, as they result from stimulation of the adult organs.

With the completion of the building of the organs, function has made its appearance. Growth unlike that of the earlier period now runs hand in hand with new forms of work. This growth continues to maturity, when it ceases, except as it is to take care of the wear and tear, so to speak, and to play a part in certain organs and tissues, such as the bone marrow, the sex glands, and the nail- and hair-beds. Atrophy then slowly intervenes. This continues to the inevitable death.

The general nature of the structure and the metabolism which leads to this sequence of changes in the organism is the pertinent biological question to-day. Child[1] in 1915 reviews the general theories that have been advanced and attempts to give a physicochemical explanation of the process. Child, appreciating the relation between the slowing of growth and the decrease in metabolism, makes the general assumption, applying the "law of mass action," that the decrease in metabolism may be explained as the result of the gradual accumulation within the cell of an insoluble substratum. Since differentiation and the development of function takes place hand in hand with this slowing of metabolism, he looks upon them also in the same light. He considers the changes in the structure—differentiation—the result of the same slow deposit of the same substratum. This substratum he conceives as one of the products of the metabolic reaction. The reaction then, like any incomplete reversible physicochemical reaction, becomes slowed and this substratum accumulates, and ceases when it reaches a certain concentration. Death is the equilibrium point for this reaction.

While there is little doubt that many heterogeneous, like many homogeneous, reacting systems reach their equilibrium by this route, there does not seem to be sufficient evidence to show that the body is exactly of this kind. Again, all such systems which do arrive at such an equilibrium are first put together by some external force. In nature one cannot obtain more energy from any system than what has been put into it. *This is the law of the conservation of energy.* Child looks upon rejuvenation, then, as the result of the removal of this substratum and of dedifferentiation. Differentiation is not, therefore, according to Child, a change peculiar to a definite period, but

rather the result of growth, or the dynamic state of the cell. Senescence is an inevitable consequence suffered by all cells, whether they be unicellular organisms or cells of the metazoa. To put it in his own words, "Senescence is a necessary and inevitable feature of growth and differentiation, while rejuvenescence is associated with reduction." Differentiation he defines as a process of specialization. It takes place in the cells when they are suffering a moderately active metabolic rate. Decrease in this rate favors differentiation. Increase it and dedifferentiation tends to occur. Reduction is different. It is not the reverse of growth. Growth is the "accumulation of certain substances formed in the course of the reaction which are physiologically more stable than other substances that break down, furnish energy, and are eliminated." Reduction takes place when the breakdown is not balanced by the synthesis. Using Child's own data, I see no reason why this process may not be formulated, however, in a much more definite manner and in a manner more consistent with not only other natural phenomena, but also with the picture of development and later life as they have presented themselves through morphological studies. In the early periods of development, just after the fertilization of the egg, the rate of metabolism is high. The work performed during this period is the building of a heterogeneous mass out of a previous simple egg cell. This process of building is completed early. The metabolism at the time of completion is lower than at previous times, but it is still high. Subsequent to this time this metabolic rate, then, declines progressively to death. The picture at the beginning is therefore entirely different from the later one. It is the building of the machine, which, when once established, slowly runs down. The picture in development is that of the forcible putting together of parts, which are then to react with one another to produce work. This reaction continues in each case to an equilibrium or death, like any such machine built by man. While the metabolic rate is high in this machine it grows. This growth ceases (maturity) when this metabolic rate reaches a certain minimum. Then atrophy slowly sets in. Normal death is not the accumulation, but the gradual using up of the parts. It is the passing of heterogeneous system to a state of equilibrium.

Such an explanation looks upon the life of the organism, therefore, as the result of some unknown force, active only in its early period, beginning with the fertilization and ending with the formation of the last organ and parts of organs. This force disappears at

birth or thereabouts. Subsequent to this time life is merely an expression of the gradual deterioration of the previously built heterogeneous system or the interaction of its various parts, which follow the law for the disintegration of all such heterogeneous systems. Life of the animal ends with the establishment of an equilibrium between the parts of the organization which produce the work that really constitutes life. The energy for the building of the first period is derived, therefore, in the later period.

Systemic or *general death* is nothing more, therefore, than the establishment of a true equilibrium, or a breakdown in one of the essential parts of the body. This is not the end, however. What we have been talking about so far is the life of the organism, and not that of the cell. The end of the individual does not mean the end of all its parts. The cells are not dead at this period. They are all intact. This system is able to reproduce itself. The normal death of the whole is not the result of the death of the cells. The cells which make up the whole are destroyed, rather, by the process of the death of the whole. These cells, as we now know, go on forever under the proper circumstances. Out of one of them in the old, the egg cell, comes a new individual. Their destruction at the death of the individual is the result of this *general death*. Their destruction is the result alone of their position. *Systemic life* and *systemic death* are something different, therefore, from *elemental life* and *elemental death*. The first has limits; the other may have none. The question is, What is the nature of this system which can show such changes? This cannot be solved by a study of the animal as a whole. It cannot be solved by the study of the amœba, because it is an animal itself. It must be solved through a study of those cells which go through these changes, those cells which find this building of an animal and the ultimate disintegration of this animal their normal means for preserving their kind. The amœba need take no such complicated route to preserve its kind. These cells of the animal must take this course in order that they survive and that the proper environment be prepared for their reproduction. Child has ignored this fact completely. He has assumed a continuous dynamic state for the cell without any proof of its existence. He has again assumed that the life of the whole is only an elaboration of the life of the cell. He has assumed differentiation to be a peculiarity of all cellular life. He has assumed the protoplasm of cell to have structure capable of performing work. The best biological work of the last century has not only added no proof for

these general assumptions formulated by the earlier authors, but quite the reverse, it has spoken against them. As Bayliss states, there is not evidence that cells are necessarily dynamic. The best morphological studies of protoplasm have again failed to show structure in many cells other than nucleus and centrosome. As Wilson clearly states, cellular growth, division and differentiation are not primary factors in development, but secondary to more formative forces or stimuli. In the simple formulation which I have given above it is possible to understand how the organism not only reproduces itself, but it expresses definite need for the differential changes as they come into existence. The energy for the primary building is acquired from the old. The old is a machine not different in principle from other machines of nature.

As I shall show in the following pages, the main criticism of Child's theory is that he utilizes theories to build theories. He accepts the idea of the cell as the unit of manifested life of the organism without question. Before any theory of *life* and *death* is justifiable of acceptance it is necessary that the true nature of the structure and the metabolism of the cell be ascertained. This is not going to be accomplished by morphological and chemical methods alone, nor by a study of the metabolism of the whole, but by methods which allow us to study directly each of the fundamental manifestations of life, such as growth, division, differentiation, migratory movement, etc. The tissue culture has given us this opportunity. In support of the above contentions it is of interest to report here some general analyses so far carried out by this method.

THE CONNECTIVE-TISSUE CELLS.

As is well known, practically all previous work on the cell in regard to the nature of its energy-producing reactions and the manner of the transformation of this energy has been based upon the idea that the cell is a highly organized body. While for years it has been assumed that amœboid movements are comparable to surface tension changes in liquids, all theories have been based upon the idea that these amœboid movements are the result of localized changes in surface tension resulting from some unknown organization residing within the cell. All modern physiochemical methods have failed, however, to reveal any such organization. This has led one and then another to assume that the organization is either the result of a slow diffusion of substance in the colloids of the cell (Wells)[5], a peculiarity of colloids not yet organized, or to invisible membranes traversing the protoplasm.

As early as 1913[7] I had noted, however, that the movement of the cell of the organism is not one which is governed necessarily by such factors.[8] These cells in the medium of the cultures move always out and away from other cells; and in further studies carried on over several years, I have continually noted that the large number of these cells show no change in contour during their movement. Their movements are not amœboid. They glide along like bodies carried by some external force.

The picture observed in these cells is not that of a highly organized body, but one liberating a surface-tension-lowering substance. Their movements are like those of cayenne-pepper granules dropped on the surface of water. When a number of such granules are scattered on the surface of the water they shoot apart. This moving apart is the result of the liberation by them of a surface-tension-lowering substance. This accumulates in greater concentration between the granules. These granules are pulled apart, therefore, by the greater force of the water surface without.[9]

While the connective-tissue cells take the same course outward, they never become completely dispersed. These cells again fail to show movement on the surface or within a liquid medium, but move only and show evidence of metabolism in the presence of the fibrinogen contained in the blood plasma which I had used chiefly as a medium. In a liquid medium these cells round off to perfect spheres. In the plasma cultures they stick tightly to the fibrin formed in the coagulation of the plasma. In contact with these fibrils they spread out to take various shapes. These shapes are always peculiar to the surface of their contacts.[10]

Not only the character of the movement of these cells, but their general effect upon the clot, further indicates that they liberate such a surface-tension-lowering substance. This substance differs in its physical properties from that liberated by the granules of cayenne pepper, however, in that it is apparently not soluble in water, but it is adsorbed or chemically combined with the fibrinogen. The cells not only stick tightly to the fibrin, but they occasion its formation. When a fragment of connective tissue is placed in a drop of plasma it occasions first a gelation of the whole of the layer, and then later a true coagulation. This gelation commences at the tissue border and spreads rapidly, to invade quickly the whole of a large area of the fluid plasma. After a considerable latent period, the coagulation, the formation of fibrin and serum, commences. This true coagulation again begins at the tissue border and spreads slowly outwards, to

involve after many days a small area about the fragment.[11] With this second coagulation the cells appear. They are in close contact with the fibrin and they glide out just behind the spreading area of change in the jellylike clot. This movement continues only so long as the process of coagulation proceeds. The cells are elongated spindles closely cemented to the fibrin, yet capable of gliding on its surface. With the completion of the coagulation their movement ceases. They come to rest. In this state they will remain apparently indefinitely unless fresh fibrinogen is added. When this is added they again occasion its coagulation, move into it, and again come to rest when the coagulation is completed.

The whole picture of activity in these cells is that which can be readily interpreted in terms of the liberation by them of some substance insoluble in body fluids, but readily adsorbed or chemically combined with fibrinogen. The combination leads to the formation of fibrin. The movement and the clinging of the cell to the fibrin indicates further that this substance is one which has strong affinities for the cell. These cells do not crawl, but they glide, and are held firmly to the fibrin. Their gliding is directly proportional to the spread of the coagulant. Such can take place only in presence of a substance which is strongly attracted, not only by the fibrinogen, but also by the cell. Energy production in these cells is centered, therefore, about this substance. How it is formed in the cells becomes, then, a problem of interest. The fact that the cells come to what appears to be complete rest in the coagulated clot indicates that it is the product of the one reaction taking place within them.

For several years it has been evident that energy production in the body is the result of chemical change. It is further recognized, as Bayliss[6] clearly points out, that hydrogen and carbon enter chiefly into this reaction. Nitrogen in the body is used largely for the building of the substratum, proteins, in which these reactions proceed. This indicates that the reactions leading to protein syntheses are different from those producing energy.

What has not been shown is the nature of the products formed in this energy-producing reaction. It has been thought that oxygen enters directly into this reaction, and at one time it was thought that the products formed were largely carbon dioxide and water. Recent careful experiments have indicated that this is not true. Fletcher[12] has shown clearly that oxygen does not enter into the contraction phase of muscle, but is adsorbed largely in the recovery

period. Muscle may contract for a time without oxygen. J. Loeb[13] has found that oxygen is necessary to preserve the structure of the fertilized egg. These experiments of J. Loeb also indicate that the metabolic reaction may proceed without oxygen. That the same is true for the animal cells has long been known by pathologists. Cut off the blood supply from any part and it undergoes a coagulative necrosis. These observations suggest strongly, therefore, that oxygen plays a necessary but probably a secondary rôle in this reaction. It acts to remove certain products of the primary reaction rather than enter into it.

All chemical reactions, as it is now fully appreciated, are governed not only by the concentration of reacting substances, but also by the concentration of one or all of the products formed. Equilibrium for a simple reversible reaction is expressed in the following formula:

$$A + B + C + \ldots = A' + B' + C' + \ldots$$

In the animal organism growth is not determined by food any more than it is determined by oxygen, but by other unknown factors. Bardeen showed that planaria regenerate their parts when starved as when they are fed.[14] Morgan found that salamanders regenerate their legs as rapidly when starved as when fed.[15] The difference is that the starved animals suffer marked emaciation and a general atrophy of their organs.

The above observations of the connective-tissue cells indicates clearly the existence of a previously unrecognized product of cell metabolism which is evidently insoluble in liquid medium, but rapidly adsorbed and chemically combined with fibrinogen. This substance, which I shall designate as "L," is also an active blood coagulant. It is something, therefore, which is insoluble in water, but capable of combining with fibrinogen to form an insoluble combination, fibrin. It acts in every regard, therefore, like the lipoid fraction of the blood coagulant recognized by Woolbridge[16] and recently carefully studied by Mills.[17] This fraction is a phospholipin or a group of such bodies.

In a recent series of experiments[9] I undertook, therefore, to ascertain more carefully the exact relation to this substance of the general chemical changes of these cells. These cells had apparently become inactive after they had come to rest in the clotted fibrin. They had laid for months in this inactive state and in the presence of oxygen. When removed to fresh medium they had again become actively migrating cells. I removed the oxygen from about these cells during their movement and also after they had come to rest.

While they are migrating and the coagulation is taking place they disintegrate in the absence of oxygen. They suffer a coagulative necrosis. After they come to rest they suffer no change in the absence of gas. In the same way, these cells suspended in a liquid are unaffected by the absence of oxygen. In a liquid they do not metabolize any more than in the presence of a fully formed fibrin. Any slight stimulus which occasions their movement occasions also their disintegration in an atmosphere of nitrogen.

There seemed little doubt, therefore, that in the identification of this "L" substance the regulator of the metabolism of these cells had been found. It is not something which is continuously washed away by the blood stream, but, quite to the contrary, it has very specific affinities, and when brought into contact with fibrinogen it forms an insoluble fibrin. This suggested strongly, therefore, that continuous activity in these cells must depend not alone on food and oxygen, but also upon very special conditions for removing these primary products from the cell.[9] The only plentiful substance which I have been able to find in the adult body capable of such removal is fibrinogen. This is transferred by the "L" substance into fibrin. In the body the messenchyme cells of older embryos and the connective-tissue cells of adults lay down extracellular fibrils. Hertzler[18] has shown very definitely that fibrin forms the basic proteins of these extracellular or collagen fibrils.[19] These results of Hertzler have been confirmed by Baitsell[20] and myself.[11]

These observations indicate that the connective-tissue cells of the body are not in any sense continuously active. Their only function is the production of extracellular fibrils. They do not secrete these fibers, but coagulate certain proteins formed elsewhere in the organism. The increase in these fibrils is alone indicative of an active metabolism in them. The dynamic state of the organism is in no sense, therefore, an elaboration of the dynamic state of these cells. It must depend on other conditions. This led me to investigate more carefully the process of rhythmical contraction as it is seen in heart-muscle cells.

In my earlier studies of the tissue culture I had already shown that differentiation in heart muscle is a purely reversible phenomenon.[21] The actively contracting heart-muscle cells are derived primarily from the undifferentiated mesenchyme. When the fragments of this tissue are brought into contact with the plasmatic medium of the culture the heart-muscle cells at the edge of the fragment which had been contracting lose this property at once. They migrate into

the medium and behave exactly like the simple undifferentiated mesenchyme cells. In 1912 I[21] showed, however, that in a few cases these cells which migrate into the medium may differentiate again and develop rhythm. When this takes place it is interesting to note that the cells by chance alone had come into a very peculiar relation with the medium, and again it is interesting to note that this rhythm never develops while the cells are migrating, but always after such migration has ceased and the coagulation process is complete.

The differentiation of the heart-muscle cells in the outer medium takes place very infrequently. In the large majority of the culture of the older embryos and adults the clots cling tightly to the fragment. The cells migrate in contact with the surface of the fibrin fibrils. When differentiation takes place the process is different. The clot loosens and contracts away in mass. If the ends of a few cells remain attached to this clot they may become stretched through the serum cavity between the surface of the medium and the end of the fibrin fibrils, or between the fragments and the end of these fibrils. After the coagulation is complete, these cells, and these cells alone, develop rhythm. If they be removed from those contacts and be placed in the outer medium in contact with the surface of the fibrin they stretch out again and behave like simple mesenchyme or connective tissue cells.[9]

By these observations it became possible, therefore, to clear up the difficulty of the earlier observations of the connective-tissue cells. Dynamic states in the organism, such as the heartbeat, are not a property of the cell, but that of a peculiar organization of the environment. These cells may produce the energy for the work of the body, but there is no evidence that the transformation of this energy into work is the product of a cell organization in the case of the heartbeat any more than it had been found to be in the case of cellular migration.

What is true for the connective-tissue cells I find also to be true for the epithelial cells of the skin and many of the glands. The gland cells in the cultures lose the form peculiar to them in the organism. They stretch out, like the skin epithelium, to form broad, thin sheets of cells. These cells cannot metabolize except in the presence of fibrinogen or a similar adsorbing substance. They differ from the connective tissue in that they later destroy this substance through certain added proteolytic properties. They thus depend wholly on the fibrinogen for their activity in the culture, but they remain together and form no extracellular fibrils, in that they later

destroy the fibrin which is formed.[23] In liquid media they show no evident activity.

While these experiments are interesting for the understanding of the general problems of the genesis of connective tissue, their broader significance lies in the new view they present of life in the organism. They show that the continuous activity consistent with life is not a property of these nonfunctioning cells. There must be long periods of time when the connective-tissue cells show no activity. Life must be, therefore, wholly a part of the functioning systems, the glands, the muscles, the brains, etc. In early life, however, this cannot be true. The whole problem of life in the early embryo is centered about an excessive metabolism and an active proliferation of the undifferentiated cells of this earlier period.

Many years ago Hofmeister, Sachs and De Bary had already shown that cellular proliferation is not a primary factor in the growth of plants. They thought that the mass forms in growing plants before it breaks into cells. That the same is true for animals has been clearly enunciated by Whitman, Adam Sedgwick, E. B. Wilson and others. In development, cellular growth, division and differentiation are not primary factors, but they are again secondary to other more formative forces. Driesch looked upon this force as something apart from nature which cannot be solved. Others have not looked at it in this sense. They have considered that this early development is the result of certain reactions which occasion such a primary building. Many general physiologists have attempted to arrive at its solution through the study of colloidal swelling. It is evident, however, that such study cannot attain directly to this goal. At the best they can only indicate analogies. It occurred to me to attempt the solution by another method. The above studies were made with connective-tissue cells of adults and the mesenchyme cells and heart-muscle cells of older embryos. No careful comparison had been made of these cells with those of the younger embryos. In the younger embryos it is well known that the mesenchyme cells form no extracellular fibrils, but grow actively to form a cellular syncytium. The fibrils appear only in later embryonic and adult life.

THE BEHAVIOR OF THE CELLS OF THE YOUNGER EMBRYOS.

As I have cited in a previous article, M. R. and W. H. Lewis, in 1911,[24] noted an active movement and growth of cells in liquid medium such as simple salt solution. This, as I have just stated, is not true of the adult connective-tissue cells. Harrison[25] in analyzing

this movement noted that the sells never moved directly outwards into the liquid but always at its surfaces. In Harrison's earlier studies he had attempted to cultivate fragments of the neural tube of frog embryos in hanging drops of serum. No evident activity was observed. Success was attained only when these fragments were placed in lymph which clotted about them. In studying the movement of the cells in lymph Harrison then noted that the cells moved always in contact with the fibrin fibrils, and in his later analysis of the culture of the Lewises he found the cells migrating always in contact with the surface of the cover glass or on the free surface of the medium. Harrison[26] termed this phenomenon, as L. Loeb[27] had done, "stereotropism." He considered these cells apparently highly complex systems whose mechanism for movement is regulated through such contacts. Both authors thought this a common property of all cells.

After a careful study of the movement of these embryonic cells in liquid medium, I noted, however, that these cultures of the Lewises were applicable only for the movement and growth of the cells of the younger embryos. No activity is seen about the normal fragments of heart muscle or other mesenchyme cells of older embryos at the surface of the liquid or in contact with any solid. As I have stated above, blood plasma or fibrinogen is the one common substance of the body capable of stimulating activity in them.

From these facts it seems evident, therefore, that it is not solids in a general sense that are necessary for the movement of these cells, but specific adsorbing substances. The younger embryonic cells differ from the older ones in that they may move at the surface of the salt solution and liquid media as well as in the clot. The older cells had lost this property. This leads me then to analyze more carefully this movement at the surface of the medium. I measured the position of the cells moving at the cover-glass surface with the micrometer of the microscope. I found that these cells were not in contact with the cover glass, as Harrison, Lewis[28] and L. Loeb had thought, but that they lay often a considerable and measurable distance below it. Again, previous to the movement of the cells on the surfaces of the hanging drop, these surfaces change. They became covered by a film or scum, which made them appear leathery. The cells in every case moved, grew and divided in this film of material. This substance is not the coagulating substance "L" liberated by the other cells. It is son e-thing new, which acts evidently in place of and antagonistically to

the fibrinogen. This substance formed early in the life of the culture. It spreads rapidly to cover the whole of the medium. The cells later invade it as they invade the plasma. It differs from the fibrinogen in that it is a much more active stimulant. The cells form no insoluble compound with it. They grow actively for a time within it and invariably disintegrate. In the plasma cultures of these younger cells, a part of the cells may at first invade the clot. They soon leave the fibrinogen, however, for the surface film which has stronger affinities for them. Single cells may also liberate this substance.

While I do not know the exact nature of this substance, it is interesting to note here that this substance disappears from or its action is inhibited about fragments of undifferentiated mesenchyme and the heart-muscle tissue in the cultures between the ninth and fourteenth day of the incubator life of the chick embryo. This is not true, however, of other tissue. I have identified it in the epidermis and the liver of these embryos as late as the eighteenth day. Felix has shown the new tubules developed in the kidney of man as late as ten days after birth. While these studies are yet incomplete, they do indicate that the disappearance or the inhibition of the action of this substance is not regular, but takes place at irregular times in different tissue of these higher animals, and that this disappearance corresponds to the forms taken by the developing embryo and adult.

What might be the exact chemistry of this substance remains to be seen. It seems most plausible, however, that the secrets of the building of the body will be found in the physical properties of it. These physical properties are, first, a strong affinity for water, and, second, an ability to stimulate an excessive metabolism.

From the above observation it became evident, therefore, that the cells of the body are not in a continuous state of activity. The activity of early life is dependent completely upon the synthesis of a substance which removes the "L" substance from the cells. This substance is gradually superseded in later life by fibrinogen. Fibrinogen combines with "L" to form fibrin, an insoluble compound. In the later periods life centers about the functioning or differentiated systems. To prove this fact more definitely it became of interest to study the effect of a flowing stream of serum upon rhythmically contracting cells and the dedifferentiated muscle cells and the cells of connective tissue.

THE CONTRACTING HEART MUSCLE CELLS.

The isolated contracting heart-muscle cells which occasionally develop in these cultures from cells migrating from the fragments contract with a rhythm like that of the whole hearts or fragments of the heart transferred to the cultures. Since they occur most infrequently, contracting fragments have been used chiefly for this study.

The rhythm of the fragments and the whole hearts of younger embryos may never cease when transferred from the chick embryo to the medium. If it does it commences at once again as soon as the temperature for it is restored. During the first few minutes or hours this rhythm is regular; and in the case of the whole hearts and fragments of the ventricle, it is the same as that which occurs normally in the body. After a short time, however, it becomes irregular. There are periods of activity followed by periods of complete rest. These periods of activity, as I have previously described them, are ushered in by rapid, strong contractions. These contractions gradually decrease in amplitude and rate to the period of complete rest. After a short rest period the active rhythm again intervenes, and so on; their irregular rhythm may continue for as long as eight or nine days in a single hanging drop.

This slowing of the rhythm and rest, I concluded, was due to the temporary accumulation of waste products, the temporary lack of nutrient substances, or both. After these waste products had slowly diffused away and nutrient substances had moved in, the heart became active again. To prove this I placed several such fragments in a specially devised culture chamber. This chamber was arranged so that serum could be made to flow continuously along a cotton wick, the fibers of which transversed the layer of plasmatic medium. By this means it was possible to continuously wash the medium about the fragment. This culture has been called the "wick culture."[20] In such cultures the rhythm of the fragments remains regular during the time the serum is flowing, and this regular rhythm continues often for many days or until the protoplasm of the cells is otherwise destroyed by infection, etc. A careful comparison of the irregularities in the case of the contracting heart-muscle cells with those of the migrating ones shows interesting differences. In the case of the migrating and growing cells there are no intermittent rest periods. Migration commences after a latent period. It continues actively for a time; then gradually ceases. In the same culture there is no second recovery period.

Again it is interesting to note that the changes in the clot are different in the case of these two activities. The migrating cells liberate a substance which occasions a coagulation of the clot. About the contracting fragments from which no cells are growing no such changes are seen in the clot. Contraction in the isolated cells commences after they have ceased to migrate and show these changes.

The substance or substances liberated by the heart which prevents its contraction and which are evidently concerned with this act of contraction are soluble substances. They can be washed away with serum. The evidence gleaned from the above studies on the migrating cells indicates that the substance or substances which occasioned their migration are insoluble in the medium. They are adsorbed or chemically combined with the fibrinogen to form fibrin. The substances which accumulated to stop the activity of the heart is not the "L" substance noted above.

For the testing of the connective tissue and undifferentiated heart-muscle cells I have used a glass culture chamber (plate LII) instead of the one described in the previous paper.[29] Otherwise the technic was the same.

During the course of the study of the contracting heart-muscle cells in 1912 I had thought that the migrating cells move more rapidly against the stream and that they became more dispersed in these cultures than in the simple hanging drops of medium. These differences were observed, however, in but a few cultures. Later I noticed that the thickness of the layers of medium also affected the movement of the cells. The cells migrating from 1 mm. thick fragments, which had been placed near the edge of the hanging drop, moved more actively in the thin edge[7] than in the thicker parts of the layer within.[8] Regulating these conditions in the "wick cultures," I found that the flowing serum in no way affected the migrating heart-muscle cells, nor did it effect in any way the movement of the epithelial and connective-tissue cells in general. The only cells affected were the leucocytes and lymphocytes. In the simple hanging-drop cultures it takes several transplants to effect a complete removal of the leucocytes and lymphocytes from fragments of bone marrow, lymph gland and spleen. In these "wick cultures" I found fragments of spleen entirely stripped of these cells after seventy-two hours. The leucocytes and lymphocytes had accumulated in masses at tangled parts of the wick.

The conditions which regulate the movement of these latter cells

are evidently different from those which control the movements of the fixed tissue cells of the body. Migratory movements and growth of the heart-muscle cells are effected by a substance which is insoluble in circulating body fluids. Growth in these cells is therefore a purely physico-chemical reaction which proceeds to a condition of static equilibrium. For growth to take place it is necessary that this substance or these substances be removed. As they increase all activity ceases. This substance or substances I have designated as "L."

DISCUSSION AND CONCLUSIONS.

From these observations there seemed little doubt, therefore that the dynamic state of the organism is not in any sense an indication of a similar dynamic state in the cell. It is a product of the organization of the body. In early life the dynamic state is associated with the formation of a substance or substances which combine with or otherwise remove the "L" substance of the cell and occasion an active metabolism within them. This substance has strong affinities for water. It is thus directly concerned with the early building of the organism. It stimulates not only an excessive metabolism in these cells, but also may occasion the primary swelling of the mass. This substance disappears, or rather it ceases to be recognizable, in the early period of development. Subsequent to this period, life becomes subservient to new organizations. The new organizations, the general nature of which I have illustrated in the study of the rhythmical contractions of muscle cells, are not unique, however, for the tissue. They are peculiar to all functioning cells. The nerve fibers are stretched between the brain and an end organ. Adrian has shown that the *"all* or *nothing"* law holds for this tissue like it does for the heart. The same is true for the glands. The secretory cells are cells which have a free end and one attached to a basement membrane. Stop up the ducts of one of these glands and these cells undergo atrophy. Such observations are wholly in line with the general facts which are known concerning development. In man the kidney may form tubules up to the tenth day after birth. Other organs cease their progressive growth much earlier. No careful studies are known concerning the time the heart cells cease to divide. In the later embryonic period, at least, all growth in the heart is represented by an increase in the size of the fibers rather than an increase in the cells. In the kidneys and glands it manifests itself in a dilation and increase in length of tubules and a flattening of their

lining cells. In the wound the exudate is the active stimulus for growth. It stimulates metabolism through a direct affinity of the "L" substance for the fibrinogen. "L" combines with fibrinogen to form fibrin. The fibrin then becomes the extracellular or collagen fibrils. The cells remain active and move towards the center of the exudate until the reaction is satisfied. The end of activity is the completion of the reaction. It is the scar for the connective tissue and continuity, and the limiting membrane for the epithelial cells.

Through the analysis of the simple act of changes of shape and the movement of the connective-tissue cells it has been possible to show that these acts are not the result of any complex cellular organization, but a simple reaction between substances in the environment and a substance of the cell. The movement is the result of the cohesion of this substance for the cell on one side and specific substances in the medium on the other. In this act of locomotion the cell supplies the energy; the mechanism otherwise resides wholly in the environment. Again, in other studies I have been able to show that the syntheses for growth are not a part of these energy-producing reactions, but they are separate reactions. The connective-tissue cells in the adult organism are widely separated in a mass of fibrillar substance. These cells migrate into the plasma, but they do not grow. In the plasma culture, growth is peculiar alone to the more cellular fragments of embryonic tissue, granulation tissue or sarcomata. By the use of embryonic extracts it is possible to stimulate the metabolism of these connective-tissue cells. Under these conditions the widely separated cells of the adult fragments will grow and divide. About the more densely cellular fragments such stimulation is not necessary. It is harmful. It leads to the destruction of the cell, a breaking down of the proteins of the protoplasm. If these same fragments are teased apart so the cells become more dispersed, growth ceases again. For growth to take place it is necessary that the cells be either crowded or excessively stimulated. The important factor for this reaction is evidently the concentration of certain products of their metabolism. The concentrating of such products may be induced by the crowding of cells or increasing the rate of their production. These cells liberate not only the "L" substance, but also CO_2 and H_2O. How many other substances are formed when the reaction is proceeding has not been determined. Protein synthesis is not a part of the ordinary metabolic reaction of the cell. It is secondary reaction depending upon and obtaining the

energy necessary for it from the energy-producing reaction of the cell. The extracellular fibers of the connective tissue are not secretions of the cells any more than bone or cartilage are of this origin.[5] These fibers are the combination of proteins formed elsewhere in the body and the "L" substance of these cells.

There is no reason to believe, therefore, that protein synthesis is a part of the metabolism of the cell. It is something different. It is a form of work produced. Upon it growth depends. Growth has never been shown to be of a simple chemical or physical nature. It is the result of the careful utilization of energy. It takes place against the forces of nature. Protein synthesis, like muscular contraction, is only a form of work peculiar to body organizations and not cellular organizations.

In 1917,[30] and again in recent experiments,[9] I have shown that the development of ryhthmical contraction is not associated with any fundamental change in the cell. This is a property peculiar to any of the mesenchyme cells of early embryonic life. It occurs in the fragments of this tissue and in the cells which migrate from them. Its development is the result of a chance relationship of the cells to medium. This relation is wholly dependent upon the physical peculiarities of the coagulation of the plasma clot. The isolated cells which develop rhythmical contraction are those cells which become stretched through a serum cavity between the surface of the medium or a cellular tissue fragment and the end of fully formed fibrin fibrils. No contractions develop until these fibrin fibrils are fully formed. What is true for the isolated cell is also true for the fragments. Fragments of the heart of young embryos contract at once when removed to warm medium of the culture. Those from older embryos fail to show this change. Rhythm develops in these latter fragments only after the border cells have moved out or the process of coagulation is completed. The end of the cell in contact with the fibrin is in metabolic equilibrium. These cells imbedded in fully formed clot cease all activity. The cells floating in serum also show no change. The only active part of these cells differentiated for contraction is the free end in contact with the cellular fragment or the surface of the medium. This end suffers a decrease in surface tension. Such a decrease in surface tension is associated with electrical changes at this end of the cell and a stretching of the cell. If such changes continue, one of three conditions must result: the cell will be torn loose or in two, or there will be an explosive breakdown of this

surface-tension-lowering substance. That such an explosive breakdown is peculiar to the contraction is clearly indicated by correlating these observations with those of Fletcher. Fletcher has found that lactic acid is liberated during the contraction phase of muscle. I find that lactic acid increases the surface tension of the cells. It causes the cell to contract. This lactic acid disappears again during the intermittent rest period. The cell again returns to its former state. The process is rhythmical. The process, as it is evident, is somewhat similar, therefore, to the phenomenon described by Bredig. Bredig showed that when a ten per cent solution of H_2O_2 is placed over the surface of pure mercury, a film of mercury peroxide forms at the surface. This leads to electrical changes in this system. Under appropriate conditions the peroxidate breaks down again to mercury and oxygen. Then the layer of peroxidate reforms. The process is repeatable or rhythmical. Bredig and his students further find that many conditions which alter rhythmical muscular contraction also alters the activity of this model.[31]

Rhythmical muscular contraction is not, therefore, as Bayliss suggests, the result of rhythmical stimuli, but evidently the result of an explosive breakdown leading to alternate changes, not only in surface tension, but in the electrical conditions at opposite ends of the cell. Bernstein[32] several years ago had given definite evidence to show that the energy of muscular contraction is surface energy. He found that muscles suffer the thermal changes peculiar alone to surface energy.

In such organization, as it is well recognized, there is no reason that such an explosive breakdown should always occur. Such is possible only when the decrease in surface tension at the free end or the electrical changes are of such a degree to allow a current to pass through the resistent cell. This change at the free end may cease before such is possible. For a breakdown to take place other special conditions or stimuli must be present. That this is the condition of most of the functioning tissue of the body has been well proven by the studies of tissue autonomy. In man, whether any muscular tissue, other than the nodes of the auricle, are autonomous, like the cell of the culture, I think is questionable. At the same time it is evident that any functioning tissue may develop such a condition. Whether this is what has happened in many of the nervous affections might be a problem worth investigating. It is not surprising, however, that in other animals the autonomy is centered in other tissues. Carlson[33] finds that the rhythm of the heart of the limulus is not automatic, but centered in certain

ganglion cells. In men I think it is very questionable whether the nervous system, any more than the striated muscle or gland cells, respond without the aid of external conditions. It is upon this fact that coördination depends.

There is no evidence from the above observations that the cells themselves undergo any absolute changes during these fundamental changes in the body. For a good many years it has been well known that bone and cartilage are products of a given organization of the part and not a product of the cell. It has been shown, for instance, that bone will develop in the pelvis of the kidney if the blood vessels to that organ are ligated. Asami and W. Dock[34] repeated these experiments in the laboratory and proved completely the existence of these changes, as the other authors had shown. In the tissue culture the cells migrate readily, not only from fragments of interstitial tissue, tendons and fascia, but also from fragments of bone and cartilage. The bone cells and cartilage cells behave in every way like the other connective-tissue cells. The bone and cartilage remains behind like the extracellular fibrils. In the same way the adult muscle fiber will not react in the plasma, but I have seen the nucleus and sarcoplasm migrate out and leave the adult fiber behind. In the plasma this mass forms perfect connective-tissue cells. These cells react also in every way like the ordinary connective-tissue cells.

Such simple fluid systems may not only suffer changes in shape and differential changes of tension at various points on their surface, but they may also suffer additions and probably subtractions from themselves. In the body differentiation is not only the result of mechanical changes initiated and controlled by the environment, but it may be also chemical in nature. As the above studies of the skin epithelium show, these cells do not suffer fundamentally from the connective-tissue cells. For metabolism to take place within them it is necessary that the "L" substance be removed from them. This "L" substance is not different in these cells from that of the connective-tissue cells. These cells differ from the connective tissue in that they also contain a proteolytic ferment. The pancreas cells again differ in that they also contain a fat-splitting ferment. They often fail to migrate into the clot. They lead rather to the rapid splitting of the fat of the plasma to fatty acid crystals. This prevents also the migration of the connective-tissue cells from these fragments into the medium. So in each case the various tissues differ as they contain their own peculiar added products. The fun-

damental reaction of the fixed tissues otherwise remains the same. The only exception to this rule is to be found in the wandering cells. These cells have not been observed to grow in the cultures. They have also lost their ability to cause a true coagulation of the plasma. They occasion the gelation of the clot and can move only in contact with this jellylike mass, but they cause no fibrin formation. They owe their spherical shape to their inability to form true surfaces in the medium. They move by a mechanism different from the fixed tissue. They can invade these fixed tissues in the presence, at least, of an exudate. When this disappears they tend to move back into the lymphatics and blood capillaries. They do not repel strongly the moving fixed tissues like the fixed tissues repel each other. They have lost the property to form the "L" substances. I say they have lost it because it is present in the mother cells from which the wandering cells arise.

To what extent this chemical differentiation is reversible like that peculiar to the mechanical form I have not definitely determined. There is evidence to show that the mesenchyme cells may arise from epithelial cells even in late embryonic life, but for the most part these epithelial cells maintain their chemical peculiarities for a long time in cancerous growths and in the cultures. I have seen heart-muscle cells assume the characteristics of large mononuclear cells. The reverse has not, however, so far been proven. Again I have seen liver cells, after repeated transplantation, behave in part at least like the connective-tissue cells. There is no reason to believe, however, that such chemical dedifferentiation may not occur and maintain in the proper environment.

The cells of the organism are not, therefore, highly complex systems. They are not equipped to lead an independent existence. They do not age. They have no organization for work. They produce the energy, but the work or their various manifestations of life is dependent wholly upon external conditions about them. The only form of work depending on an evident internal organization is cell division. The forces active in the process center about the centrosomes. There is no evidence, however, that activation of these centers, or even their formation, is controlled from within. The centrosomes develop probably alone in response to external stimuli (see Hertwig, Meade, Morgan, J. Loeb, E. B. Wilson[3] and others).

Energy production in these cells is again wholly dependent upon organization, or the presence of specific substances which split or otherwise make the removal of the "L" substances possible. Their

activity in early life is dependent upon the synthesis of a substance which combines or otherwise removes the "L" substance. In later life it is dependent upon a mechanical differentiation. This form of synthesis in later embryonic life forms a substance which is fibrinogen or closely akin it. This forms an insoluble compound with "L" rather than the soaplike substance of the earlier period. In the proper environment it occasions, through its coagulation, the form necessary for the dynamic state.

By these observations it has been possible, therefore, for the first time to define differentiation in other than morphological terms, and to compare function with growth. The growth of the undifferentiated cells of early life is the result of a special synthesis. The development of function is the result of a slightly different one. Differentiation is quite different, therefore, from what it has been conceived to be.

While these observations reduce growth and function to simple physicochemical formulation, they give no hint as to the cause for this change in synthesis from early to late life. Any substance which removes the "L" causes an immediate loss of mechanical differentiation. The heart-muscle cells in contact with the fibrin become simple mesenchyme cells. Only under proper mechanical conditions can they redifferentiate. What is true for the heart is true for the glands. In the cultures the gland cells stretch to form membrane like the skin. They lose the form necessary for function.

These facts, again, do not explain chemical differentiation. In the above observation I have also not discussed all the deficiency of these cells. Besides the lack of any organization for work and any means within themselves to allow the energy-producing reaction to proceed under the ordinary conditions in nature, they are also bereft of the property of using the crude material of nature for this energy-producing reaction. While energy production in the body is derived chiefly from H and C, these cells cannot use the sugar carried to them by the blood stream without intervention of substances from the pancreas. The organization of the whole or certain of its parts are again essential for another of their important needs.

It is upon this last deficiency that the chemical syntheses peculiar to differentiation must depend. The body is a machine operated like any other machine in nature. Its metabolism has no complexities, as most biologists would have it. It is a machine which is able to produce energy and transform it into work. It has been possible to locate these different reactions. The energy is produced in the cell;

its transformation is under the control of the environment. Protein synthesis is in no way to be confused with the energy-producing reaction. In the body, anything which increases metabolism will lead to growth. Increase this still more and protein destruction results. This accounts for the appearance of split products of protein in muscle which has suffered excessive stimulation (see Bayliss for literature) and the destruction of the tissue by strong growth stimuli such as X-ray, radium, coal tar, arsenic, etc.

Such a machine can build itself in the manner that it does because it utilizes the products of its energy-producing reaction for its building. The building is only the sequence of change its original fundamental structure undergoes to produce the final necessary work—the work of supplying an adequate amount of fuel for a certain period of life and supplying the egg with an adequate supply of this material (yolk) to carry it through the early period of the development of the whole. This yolk supply decreases progressively. This decrease leads to the changing character of the syntheses.

The extracellular deposits which I have described above as important for the organization peculiar to the dynamic state of later life are evidently the substratum recognized by Child. They are the result of protein syntheses peculiar to the organization of a certain period of the development of the whole. They must be the result not only of mechanical but also chemical changes in the environment. The picture of the organization as it is seen through the study of the cells is in no sense the picture of one continuous metabolic change. It is the primary building of a heterogenous system followed by the gradual decline of this system to a state of static equilibrium. *Elemental life* and *elemental death* are not comparable to *systemic life* and *systemic death*. The body is the necessary cycle that these cells may preserve their kind. For the active growth of the early period of the development the cell draws upon the yolk or the mother for its supply of those substances necessary for this growth. The disappearance for this supply of material is the appearance of the second, or the functioning, period. The building of this period is completed within ten days after birth in man, except for the laying down of the nerve sheath. The syntheses peculiar for this building are the result of the disappearance of the substances carried in the yolk. The important factors for differentiation are not to be found, therefore, in the primary reactions of the cells, but in the deficiencies of these cells. The important deficiency which

has to do with differentiation is their inability to utilize the crude food materials supplied by nature. This deduction we are forced to believe, however, not only from the above observations, but from a host of already carefully accumulated facts. If the first two blastomeres of many lower forms are separated, two animals develop. The yolk is also separated by this process. Each animal is but one-half the size. Gudernatsch has shown that tadpoles fed upon thyroid differentiate within a few days, while thymus feeding delays this process at least for a very long time. Very large tadpoles may be thus developed. The ultimate heterogenicity thus developed is essential for subsequent life and for reproduction. The egg cell builds a new system like the old (heredity), in that it has acquired from the old a supply of those substances necessary to carry it through the building of the new system, which is again capable of preparing these substances from the crude materials available in nature without. The building results from the changing syntheses which result from the gradual decreasing yolk supply. The form of the building is dependent, therefore, primarily on the original constitution of the yolk. This is again dependent absolutely on the nature of the machine which produces it. Each animal must, therefore, in each case reproduce its kind. The problem of heredity is thus reduced to pure physics and chemistry.

Death in such a system may result, therefore, from the destruction of essential parts, or the inevitable equilibrium of those forces which maintain the heterogenicity. This does not mean a fundamental change in the cell. The cell succumbs as the result of this breakdown. There is no reason why any of these cells may not grow actively again if the organization is changed about it. Differentiation is both chemical and mechanical in nature. Chemical differentiation does not effect the fundamental energy-producing reaction of the fixed tissue cells. It is an indication of the chemical heterogenicity of the mature organism. The mechanical differentiation essential for the dynamic state is reversible. According to the above formulation, mechanical differentiation in early life is the result of the removal and decrease in certain materials of the yolk. If a change in organization suitable for active growth should take place in the organism, no such differentiation should follow. The cells suffering such changes must continue to grow as long as the body supplies the necessary substances. The body must supply those substances necessary for active growth as long as it survives.

A rapid utilization of these substances must lead to a rapid atrophy and death, according, also, to the formulation given above.

Such a reorganization, it is evident, cannot take place in early life except under the influence of most powerful external stimuli or developmental defects. It becomes, however, more possible in later life when the normal forces which maintain the normal heterogenicity are waning. Cancer represents such a form of active growth. It is a disease peculiar to later life. It occurs earlier in connective-tissue areas than in epithelial tissue. The connective-tissue cells, according to the above observations, lose their property for independent growth earlier than the epithelial tissue.

In previous publications[9] I have noted that cancerous tissue grows like that of younger embryos and liberates the same or a similar growth stimulus.[35] In the body cancer may result from congenital abnormalities, such as pigmented moles. It occurs more frequently in certain families of mice (Maude Slye). It follows the continuous application of many growth stimuli or substances capable of effecting such a reorganization. In man, as pathologists agree, it follows most frequently upon long-standing chronic inflammation (Billroth).[36]

As has long been fully appreciated, the impediment which has stood in the way of advance in cancer has been the inadequacy of our knowledge of the cell and its relation to the whole. It has been the endeavor of the cancer laboratory in St. Louis to attack the problem from this route. Cancer is not a parasitic disease. It is a disease which follows after long, continuous stimulation. Before cancer can be understood it is necessary that irritability and stimulation be reduced to simple terms. The essential conditions for mechanical dedifferentiation, or loss of function, and the production of an active growth of cells like that of cancer is the presence of substance capable of removing the "L." This "L" has many of the properties of the phospholipins isolated by Mills. These phospholipins are soluble in many lipoid solvents, and especially products of coal tar. We have studied the action of coal tar, and find that it behaves in the tissue like the substance liberated by the cancerous tissue and the tissue of young embryo which is able to combine with or otherwise remove the "L" from the cells. Coal tar thus attracts the cells to it and effects their dedifferentiation. At first it occasions their disintegration. Later it becomes a less active solvent and occasions an active proliferation of these cells. It is capable not only of producing many of the symptoms of cancer by itself, but of

effecting the reorganization necessary for true cancer to develop. Long use of coal tar leads to the development of cancer.[35]

What I have hoped to present in this paper is not only the general picture of the cell the tissue culture has so far revealed, but methods by which the further details of these general problems may be attacked. From the above observations it is evident that the problems relative to life are not to be solved by chemical and morphological methods, but by the application of mechanism. Heredity, as we have seen, is dependent wholly on the chemistry of the system, but the importance of these chemical substances will not be understood until the mechanisms peculiar for the various manifestations of life have been isolated, their parts and the energy relation between these parts have been fully determined. Upon this latter knowledge rests also the ultimate control of cancer. Cancer, as it has been seen, does not arise from embryonal cells. It is not the mere displacement of cell (Ribbert), but a specific reorganization of parts. Such a reorganization means a breaking down of the normal relation of cells in the adult. The normal heterogenicity is maintained through the fact that each kind of cell moves through the liberation of the same surface-tension-lowering substance. Each tissue repels its neighbor like each cell repels each other cell of the same or of another kind. It is a breaking down of this barrier through the synthesis of a new substance which conditions new surface relations. It is an invasion of connective tissue by the epithelium (Thiersch and Remak). This synthesis becomes possible through the specific rearrangement of cells. Such rearrangements may result from developmental defects or through the action of stimulating substances. In the body not only quality but quantity is an absolute factor. *Systemic life* and *elemental life* are not comparable. The cells do not age. Differentiation is not an age phenomenon. The law of the conservation of energy holds for the body like it holds for all natural phenomena. Advancement in biology is to be made through the development of methods for the study of the mechanics of these systems. Morphology and chemistry must be supplemented by these methods. All parts of these machines are not visible. Rhythmical heart-muscle contraction is not a specific chemical reaction. It is peculiar to a large number of animals. These animals differ chemically from each other. A watch is a watch whether it is made of gold or silver.

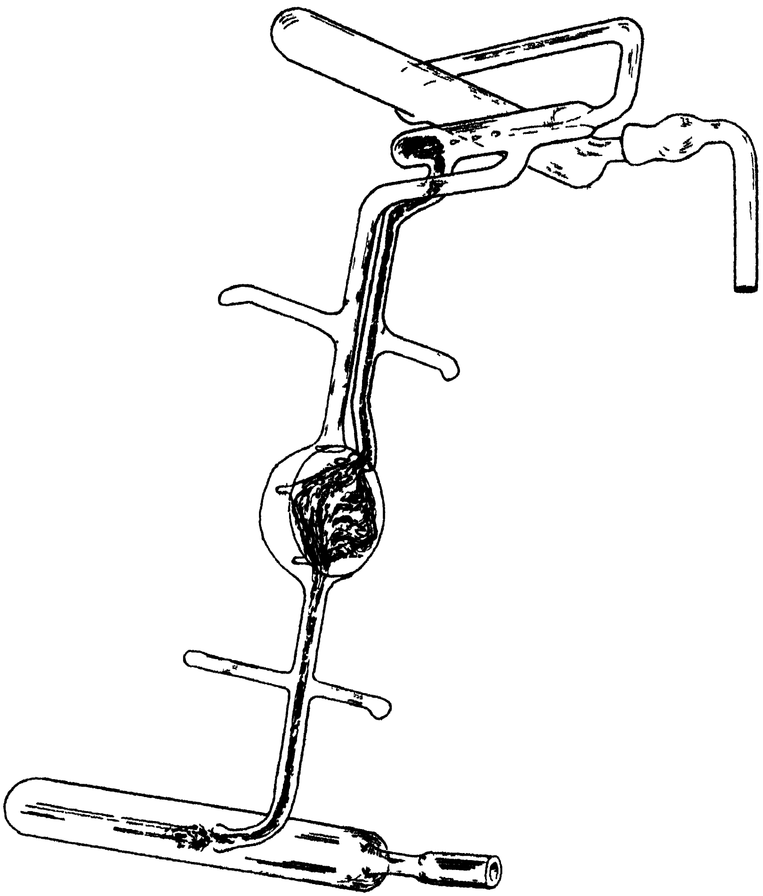
The heart contracts as the result of a special arrangement of its parts and the specific dynamic properties of these parts, and not through the specific chemical constitution of the particular protein which compose its parts.

BIBLIOGRAPHY.

1. CHILD, CHARLES MANNING. 1915. Senescence and Rejuvenescence. The University of Chicago Press, Chicago.
2. THOMPSON, D'ARCY W. 1917. Growth and Form. University Press, Cambridge, London.
3. WILSON, E. B. 1906. The Cell in Development and Inheritance. Second edition. London and New York.
4. HUXLEY, T. H. 1863. Review of the Cell Theory. British and Foreign Med. Cir. Rev., vol. XII.
5. WELLS, H. GIDEON. 1914. Chemical Pathology. Second addition. Philadelphia and London.
6. BAYLISS, W. M. 1915. Principles of General Physiology. London.
7. BURROWS, M. T. 1913. The Tissue Culture as a Physiological Method. Trans. of the Congress of Am. Phy. and Surg., vol. IX, pp. 77-90.
8. BURROWS, M. T. 1913. Tissue Culture *in vitro*. XVII the International Congress of Medicine, General Pathology and Pathological Anatomy, London, pp. 217-237.
9. BURROWS, M. T. Titles Read May, 1923, to Appear in Oct., 1923, Proc. of the Society of Exp. Biology and Medicine, vol. XXI.
10. BURROWS, M. T. 1911. The Growth of Tissue of the Chick Embryo Outside the Animal Body with Special Reference to the Nervous System. Journal of Exp. Zoöl., vol. 10, pp. 63-83.
11. BURROWS, M. T. 1916-'17. Some Factors Regulating Growth. Anat. Record, vol. 11, pp. 335-339.
12. FLETCHER, W. M. 1902. The Relation of Oxygen to the Survival Metabolism of Muscle. Jour. of Physiol., vol. 28, pp. 474-498.
13. LOEB, JAQUES. 1913. Artificial Parthenogenesis and Fertilization. Chicago University Press, Chicago.
14. MORGAN, T. H. 1901. Regeneration. New York and London.
15. MORGAN, T. H. 1906. The Physiology of Regeneration. Jour. of Exp. Zoöl., vol. 3, pp. 457-500.
16. WOOLBRIDGE, T. C. 1893. On the Chemistry of the Blood, and Other Scientific Papers. The Crotian Lecture on the Coagulation of the Blood. London.
17. MILLS, C. A. 1921. Chemical Nature of Tissue Coagulins. Jour. of Biol. Chem., vol. XLVI, pp. 135-165.
18. HERTZLER, A. E. 1904. Peritoneal Adhesions, Their Cause and Prevention. Tr. West. Surg. Assoc., vol. XIV, p. 76; Anat. Rec. 1915, vol. IX, p. 83.
19. HERTZLER, ARTHUR E. 1919. The Peritoneum. Vol. 1, chap. V. St. Louis.
20. BAITSELL, G. A. 1916. The Origin and Structure of Fibrous Tissue Formed in Wound Healing. Jour. Exp. Med., vol. XXVIII, pp. 739-756.
21. BURROWS, M. T. 1915. An Attempted Analysis of Growth. Anat. Record, vol. 9, No. 11. *And,* The Tissue Culture in Cancer. Proc. Second Pan-Amer. Sci. Congress, Washington, section VIII, part 2, pp. 494-496.
22. BURROWS, M. T. 1912. Rythmische Kontraktionen der isolierten Herzmuskelzelle ausserhalb des organismus Mumchener medizinischen. Wochenschrift, No. 27, pp. 1-10; and Science, N. S., XXXVI, pp. 90-92.
23. BURROWS, M. T. 1913. Wound Healing *in vitro*. Proc. of the N. Y. Path. Soc., N. S., vol. XIII, Nos. 5 and 6.
24. M. R. AND W. H. LEWIS. 1911. The Cultivation of Tissues from Chick Embryo in Solution of NaCl, $CaCl_2$, KCl and $NaHCO_3$. Anat. Rec., vol. 5, pp. 277-294.
25. HARRISON, R. G. 1911. On the Stereotropism of Embryonic Cells. Science, N. S., vol. XXXIV, pp. 279-281.

26. HARRISON, R. G. 1914. The Reaction of Embryonic Cells of Solid Structures. Jour. of Exp. Zoöl., vol. 17, pp. 521-544.
27. LOEB, LEO. 1922. Agglutination and Tissue Formation Science, N. S., vol. LVI, pp. 237-240.
28. LEWIS, W. H. 1922. Is Mesenchyme a Syncytium? Anat. Record, vol. 23, pp. 177-184.
29. BURROWS, M. T. 1912. A Method of Furnishing a Continuous Supply of New Medium to a Tissue Culture *in vitro*. Anat. Record, vol. 6, pp. 141-144.
30. BURROWS, M. T. 1917-'18. A Note on the Mechanism of Heart-muscle Contraction. Am. Jour. Physiology, vol. 45, pp. 556-557.
31. BREDIG, S., UND WEINMAYER, J. 1903. R, periodische Kontaktkatalyse. Zeitsch fur Phys. Chem., B. 42, S. 601-611. *And,* Bredig, S. 1907. Bio-Chem. Zeitchr., B. 6, S. 283.
32. BERNSTEIN, J. 1908. Uber die Temperaturcoeffizienten der Muskelonergic. Pfluger's Arch., B. 122, S. 129-195.
33. CARLSON, A. J. 1904. The Nervous Origin of the Heartbeat in Limulus and the Nervous Nature of Coördination or Conduction in the Heart. Amer. Jour. Phys., vol. 12, pp. 67-74.
34. ASAMI, GOICHI, AND DOCK, WILLIAM. 1920. Experimental Studies on Hyperpastic Bone Formation. Jour. Exp. Med., vol. XXXII, pp. 745-766.
35. BURROWS, M. T. 1923. The Experimental Production of Malignant Ulcers in the Rat. Mo. State Med. Jour., vol. XX, pp. 145-147.
36. EWING, J. 1919. Neoplastic Diseases. Philadelphia and London.
37. L. H. JORSTAD. A Study of the Behavior of Coal Tar in the Tissues. Proc. of the Soc. Exp. Biol. and Med., Oct. 1923.

PLATE LII.



The 'wick culture' chamber.

THE

KANSAS UNIVERSITY SCIENCE BULLETIN

VOL. XIV, NO. 20—OCTOBER, 1922.

(Whole Series, Vol XXIV, No. 20)

ENTOMOLOGY NUMBER V.

CONTENTS:

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV.] OCTOBER, 1922. [No. 20.

Some Notes on the Biology of *Curicta** from Texas.

BY GRACE OLIVE WILEY.

BEHAVIOR OF ADULTS AND NYMPHS OF *CURICTA*.

I COLLECTED several pairs of adult *Curicta* and placed them all in one glass to take home alive. When I reached home most of them were mating. These were removed and placed in separate glasses, and remained paired for several hours.

In mating, the male takes a position to one side of the female, and usually to the right. If to the right, he hooks his left anterior tarsus over her head; if to the left, the right fore tarsus is used.

Both nymphs and adults seem fond of getting out of the water and lying close to the ground, where they are hardly discernible. I have found adults almost a foot from the water's edge, in tangled plant roots and under rotten pieces of wood. Search for eggs laid in nature provided fruitless. One pair was mating. I am half inclined to believe the eggs are laid in soft mud.†

The nymphs are very agreeable, in that they do not feed upon others of their kind, even when hungry. They like small notonectids, corixids, small carabids, fresh-water shrimp, and such. They refused small minnows, however. It is not uncommon to see three feeding quietly on one shrimp, or two feeding on one small beetle. They are very fond of mosquito larvæ.

EGGS.

Size. About 1.75 mm. long; width a trifle more than .75 mm.; diameter of crown a little less than ½ mm. Rosette of filaments at tip, numbering 15; length of filaments almost 1 mm.

* *Curicta drakei* Hungerford.

† Have now found the eggs deposited in the tissue of dead plant stems with only the crown of filaments visible.

Shape. Elongate oval, one end slightly tapering and rounded, the other smaller, sloping somewhat obliquely and bearing a crown or rosette of fifteen long filaments.

Color. Creamy white, with filaments somewhat yellowish, center of crown darker.

Seven eggs were laid by one female twelve days after mating. These were not inserted in soft wood or in plant tissues, although both were available. The female was lying close to the wet sand and the eggs were laid on their sides on the sand without any regularity or order. The next day there were three more eggs, and in three more days I found six eggs hidden among the roots of water plants and in slimy accumulations in crotch of a dead twig.

DESCRIPTION OF FIRST-INSTAR NYMPH.

Form elongate oval; very much like adult, only broader in proportion to length. Head large, much narrower than prothorax and as wide as long, excluding the rostrum. Eyes globular, small.

Anterior femur quite robust and armed with a single median tooth, plainly visible and closer to the base than the apex of the femur.

Anterior coxæ about half the length of their femora, and very robust. Intermediate and posterior legs short. One-segmented tarsi.

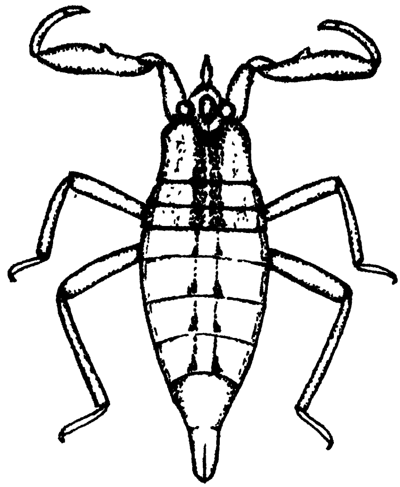
Color when first hatched pale straw yellow, becoming darker with brownish-black markings. Number of days of first instar, twelve. Entire length of insect from tip of beak to end of respiratory tube, 5 mm.; width across abdomen at widest part, 1.50 mm.; width across eyes, .75 mm.; width of shoulders at base of head, 1.15 mm.; length of prothorax on median line, 1 mm.; length of respiratory tube, a trifle more than .50 mm.; length of anterior femora, 1.40 mm.; length of anterior tibiæ, .70 mm.; length of anterior tarsi about .25 mm.; length of anterior coxæ, .70 mm.; length of intermediate femora, 1.40 mm.; length of intermediate tibiæ, 1.00 mm.; length of intermediate tarsi, .20 mm.; length of posterior femora, 1.25 mm.; length of posterior tibiæ, almost 1.50 mm.; length of posterior tarsi, almost .50 mm.

Since writing the above I have reared the insect through from the beginning. There are five instars.

PLATE LIII.

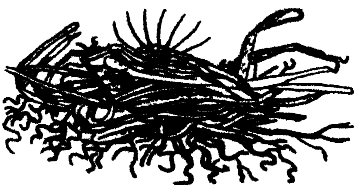
The genus *Curicta* was represented in the United States by *Curicta howardi* Mont., described from a single specimen taken at Victoria, Tex., years ago. Nothing was known concerning the biology of these bugs. The sketch of the egg and first-instar nymph are therefore of interest.

PLATE LIII.

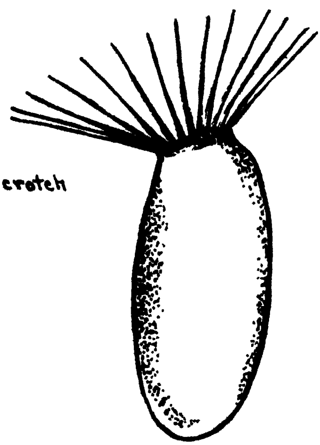


1st Instar Curicta . howardi.

Egg laid in slimy accumulation in crotch of dead twig.



Egg hidden among grass roots , part of filiment visible .



Egg of Curicta .

THE

KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV, No. 21—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 21.)

ENTOMOLOGY NUMBER V.

CONTENTS

PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

THE KANSAS UNIVERSITY
SCIENCE BULLETIN

Vol. XIV.] October, 1922. [No. 21.

Biology and Morphology of *Lepyronia quadrangularis* (Say)—Homoptera, Cercopidæ.

BY KATHLEEN DOERING

Submitted to the Department of Entomology, University of Kansas, in partial fulfillment of the requirements for the degree of Master of Arts

INTRODUCTION.

THE purpose of this paper is twofold; first to add to the limited data concerning the biology of the Cercopidæ; and secondly, to contribute to the morphological knowledge of the family, and incidentally of the order. The subject of this paper was suggested by Dr. Paul B. Lawson. Since *Lepyronia quadrangularis* (Say) is one of our most common spittle bugs, it was thought that a study of its biology, habits and morphology would be well worth while. Later when a review of the literature revealed the meagerness of both biological and morphological details concerning other species in the family, the necessity for this work was magnified.

By means of the morphological studies the writer has attempted to accomplish two things: First, since little work has been done on the morphology of any cercopid, to give a detailed description of the external anatomy, merely for the morphological interest involved; and secondly, to contribute a small share, if possible, in determining the relationships of the families within the order. A thorough knowledge of the morphology of all families in a given order seems necessary to correctly determine their phylogenetic relationship. In the literature, however, they are usually determined on the basis of a comparison of certain special parts of the body of a single species from each family. But since the species, or at least the genera, may vary within a family, some having primitive head sclerites and specialized genitalia, while others are just the opposite, it follows that a fairly thorough knowledge of the entire structure of the body

should be obtained before such relationships are determined. To this end this small contribution is made.

The writer wishes to express her appreciation to all who have assisted in this work: To Prof. S. J. Hunter for his interest and readiness to help; to Dr. Paul B. Lawson, under whose direction the work was done, and who, at the sacrifice of his own research time, gave most helpful advice and criticism; to Dr. Grace M. Charles for the correct identification of most of the host plants; to Lucy M. Hackman, Dr. H. B. Hungerford and P. A. Readio for their kindly help and criticism, and to all others who in any way have assisted in this work.

THE SYSTEMATIC POSITION.

FAMILY CHARACTERISTICS.

The Cercopidæ are distinguished from the other families of Homoptera by having three-segmented tarsus, two ocelli, the antennæ inserted in front of and between the eyes; the prothorax not prolonged backward, and the hind tibiæ armed with one or two stout teeth, with two rows of short, stout spines at the tip.

SUBFAMILY CHARACTERISTICS.

The Cercopidæ are divided into two subfamilies—Cercopinæ Am. & Serville, and Aphrophorinæ Am. & Serv. *Lepyronia quadrangularis* (Say) comes within the latter. According to Ball (1898) the Aphrophorinæ are separated from the Cercopinæ by the following characteristics: Anterior margin of the pronotum angulate; head equaling or almost equaling the pronotum in width; elytra compressed behind, rarely reticulate.

HISTORICAL REVIEW.

This insect has been described under various genera. It was first made known to science by Say in 1825 as *Cercopis quadrangularis*. In 1831 it was put in the genus *Aphrophora* by Say, and in 1851 in the genus *Ptyelus* by Walker. Amyot and Serville (1843) described it under the genus *Lepyronia,* which name it now holds.

GENERIC DESCRIPTION.

The original description of the genus by Amyot and Serville is as follows: "Corps court et remassé. Tête en cône arrendi antérieurement, sans caréne longitudinale médiane sur le vertex ni sur le front. Elytres bombées, en ovale court et en forme de coquille. Les autres caractéres sont ceux des *Aphrophores*. Du grec λεπυρόν, coquille d'œuf."

The genus *Leypronia* is separated by Ball from the other genera of Aphrophorinæ by these characteristics: Anterior margin of vertex between front and eyes sharp; ocelli nearly equally distant from eyes and each other; rostrum short, not exceeding middle coxæ; anterior margin of pronotum rounded; corium without terminal membrane; whole upper surface densely pubescent, hiding sculpturing and venation.

KEY TO SPECIES.*

A. Margins of the vertex regularly rounding to the obtuse tip; elytra slightly angularly inflated, nearly twice longer than their combined width (folded), grayish, testaceous, with a distinct V on each elytron. *quadrangularis* (Say).

AA. Margins of vertex straight or concave, the tip slightly produced; elytra inflated, no more than one-half longer than their combined width (folded).

B. Small, testaceous, rather narrow; the vertex broad and short, shorter or only equaling the pronotum in length; apex of elytra broadly subhyaline. *angulifera* (Uhl).

BB. Large, nearly uniform grayish, general form globose; vertex longer than pronotum. *gibbosa* (Ball).

The original description of Say is given herewith:

Brownish-cinereous elytra with two oblique brown bands confluent at the outer margin; beneath black; feet annulate with pale. Body brownish cinereous, covered with dense, minute hairs, head obsoletely spotted; eyes fuscous, a pale longitudinal line on the middle, in which is a brown central line; stemmata indistinct, black; thorax emarginate at the anterior angles for the reception of the eyes, and deeply emarginate behind for the reception of the scutel; a double series of obsolete, indented spots before; scutel, tip and basal angles acute; hemelytra pale brownish cinereous; an oblique black-brown fascia from inner basal angle is confluent at the middle of the exterior margin, with an oblique fascia, which terminates near the sutural tip; tip with a small blackish curve; region of humerus dusky, beneath black; feet black; thighs annulate with pale; posterior pair of tibiæ pale, armed with two robust spines behind and numerous small ones at the tip; posterior tarsi armed with spinules at the tips of the first and second joints beneath; abdomen black; tail pale beneath.

The following is a technical description:

Form: Length: ♀ 6.4 to 7.2 mm.; ♂ 6 to 6.8 mm. Width: ♀ 3 to 3.2 mm.; ♂ 2.4 to 3 mm.

Vertex flat or depressed; length and width about equal, as long as pronotum, margins rounding to a blunt apex; tylus large, parallel margined, nearly one-half length of vertex; eyes level with vertex, distended below; front somewhat inflated, rising gradually from the sides, margins convex, slightly longer than wide; clypeus only slightly inflated, twice as long as wide; pronotum flat, twice as wide as long, slightly emarginate anteriorly with transverse rows of im-

*Ball, E. D. A Review of the Cercopidæ of North America North of Mexico. Rept. Ia. Acad. Science, 1898.

pressions behind margins; lateral margins nearly parallel, longer than short diameter of eye; elytra not quite twice as long as wide, outer margin flaring, apex angulate; abdomen broadly triangular, about as wide as long, margins and apex greatly exceeded by wings.

Color. Vertex and tylus mottled testaceous brown; minute yellow line on margins; eyes deep fuscous; face uniform testaceous brown; pronotum reddish brown at base, fading into brown cinerous; elytra grayish or tawny brown, a patch at the base, another at apex, an oblique band from tip of scutellum to a point beyond middle of costa, another from point of claws, meeting this on costa and forming a V on each elytron, brownish fuscous; abdomen blackish brown, apex paler; legs testaceous brown, annulate with pale, spines on posterior leg very black at tips.

LIFE HISTORY.

HISTORY.

Life history notes on the Cercopidæ are rather limited. Osborn (1916) made some valuable studies of the life histories of Maine froghoppers, but gave no complete history, including the egg stage and five nymphal stages, of any one species. He figures and describes three instars of *Lepyronia quadrangularis.* In 1921 Garman published the life history of *Philænus lineatus* (Linn.), wherein he describes the egg and four instars. Later Barber and Ellis (1922) described the oviposition of three species, *Philænus lineatus* (Linn.) and *Philaronia bilineata* (Say.) The most complete study of a cercopid life history is that of a foreign form, *Tomaspis varia,* which is a pest of sugar cane in Trinidad (Urich, 1913). Garman (1923) gives a complete description of the life history of *Clastoptera obtusa* (Say) and a brief description of the egg stage of *Lepyronia quadrangularis* (Say).

DISTRIBUTION.

Lepyronia quadrangularis (Say), according to the Snow collection, has been taken from four counties in Kansas, namely, Cherokee, Douglas, Neosho, and Doniphan. It is also recorded here from Atherton, Mo. Ball (1898) lists it from Ontario, New Hampshire, New York, Pennsylvania, Connecticut, District of Columbia, Maryland, West Virginia, Georgia, Florida, Mississippi, Ohio, Iowa, South Dakota, Nebraska, Colorado and Texas. Van Duzee lists it from Muskoka lake district of Canada, Lake Temagami, Ontario and Quinze lake region. Comstock says it is one of the most common spittle bugs of eastern United States.

HABITAT.

Lepyronia quadrangularis is usually associated with weed patches, and therefore might truly be called a weed insect. Yet its habitat is not quite so general as this would imply. Neither adults nor nymphs can be taken on every weed patch one runs across in collecting, but seems to be found only in particular places. The selected spots usually occur near woods or thickets. It has been taken in thickets where weeds have sprung up in open spaces, by the roadsides adjoining woods or thickets, and on the weeds growing at the edge of a wheat field and on the wheat itself. They were found in most abundance, however, in a weed patch occupying half of a city block. This plot offered a variety of host plants and shelter, such as dogwood and elm sprouts, and large patches of sweet-clover, ragweed and grasses; in fact, most of the collecting necessary for this work was done at this place, and several thousands of spittle insects must have been taken here.

HIBERNATION AND SPRING APPEARANCE.

Ball (1920) stated that all Cercopidæ except one overwinter in the egg stage. Having this idea in mind when these studies were started, it was expected that the adults soon after emerging would mate, the female lay her eggs, and the overwintering form be easily obtained. The matter, however, was not as simple as this. During the summer of 1921 adults were observed in the field until August, but no mating or oviposition took place. The following spring, toward the latter part of April, eggs were sought in the field, but none could be found. On April 29 the first instars were found. At this time Mr. C. H. Curran gave the writer two adult females which he had collected on April 1 and April 4. He stated that toward the latter part of March and April adults had been quite abundant. This evidence seemed to point to the supposition that the adults might overwinter. Throughout the summer adults were closely observed in both the field and laboratory. During August and September adults were very abundant, an average of fifty being taken in an hour's collecting. On September 27, seventy-five adults were taken; on October 9, sixty; and October 19, thirty. In one of the outside cages four adults were observed on November 23. These late occurrences were due, no doubt, to the very late season, which prolonged vegetation as well as insect life.

In the late fall, after mating had taken place, an experiment was attempted for the purpose of obtaining a premature oviposition.

Twenty adults were placed in a glass jar containing sterilized leaves and twigs and covered by cheese cloth. The jar was then placed outdoors, surrounded by ice except for a small breathing space at the top and kept in this condition for eight days. After a few days the adults became very sluggish, scarcely moving when disturbed except for a slight motion of the legs. When the eight days had elapsed they were brought into a warm room and placed in a cage in which green plants were growing. Nine out of twenty insects survived, but no oviposition occurred. Although not fulfilling its original purpose, the experiment seemed to show that the adults probably overwinter. On December 23 Mr. Beamer collected a female of this species while sifting leaves in Cherokee county. Four overwintering females were taken on April 18 and 19 of this year. The exact place of hibernation is difficult to determine. To date no adults have been obtained from the outside cage. They probably overwinter deep down under the leaves and matted grass in the cracks and crevices of the ground.

CLIMATOLOGICAL DATA.

As was stated in the foregoing paragraphs, overwintering females were taken on April 1 and April 4 in the spring of 1922, and perhaps others could have been obtained earlier, while in 1923 the first ones were taken on April 19, making a total difference of seventeen days. This great variation can easily be explained by the difference in temperature of the two years. A comparison of the two springs is given in the following table:

1922.	*Mean for month*	*Departure from normal.*	*Lowest temperature.*	*Highest temperature.*	*Greatest daily range.*
February	34.2°	+1.47	2° on 13th	75° on 21st	39°
March	44.5°	+1.4	10° on 1st	78° on 23d	36°
April	56.3°	+1.7	31° on 1st	82° on 6th	38°
1923.					
February	30.3°	—0 54	—2°	61°	38°
March	40.74°	—2.03	—1°	80°	44°

From a study of the table it is readily seen that the spring of 1922 was above normal, while this spring is below normal, which accounts for the great difference in the dates of spring emergence.

SEASONAL HISTORY AND SUMMARY OF LIFE HISTORY.

A brief seasonal history and summary of life history is as follows: The insect spends the greater part of the year in the adult form, covering a period of about ten months, and the other two months are spent in the egg and nymphal stages. Mating takes place in the fall; the females overwinter, emerging in the spring along in April. A few days after emergence the eggs are laid.

The egg stage probably lasts two weeks, followed by a six weeks' nymphal stage. The adults appear in June and feed all summer and fall until after mating, when the males probably die and the females go into winter quarters.

OVIPOSITION.

Females collected in the spring were confined on small *Solidago* and sweet-clover plants under lamp chimneys. Three females collected on April 18 died on April 23. Two of the females apparently laid no eggs. Thirty-eight eggs were found in the abdomen of one and thirty-three in the other. The third female laid in all nine eggs, one of them being found alone in one leaf and the other eight in a group in another leaf. The latter were laid in a row along the slender petiole of the *Solidago* leaf. Both leaves in which the eggs were inserted were brown and withered and were found at the base of the plant. This same female was dissected and six eggs were found in the abdomen. Another female collected on April 19 died April 23 without laying any eggs. Forty-five eggs were found in her abdomen. Two other females were taken on April 24, from one of which, at this time of writing, only one egg has been obtained. It too was inserted in a partially dead leaf.

The eggs are inserted in the plant tissue. A longitudinal slit is made in the leaf and the egg deeply inserted, so that it makes a slight bulge in the leaf on the opposite side. The slit appears to be plugged with a whitish substance, which probably is part of the plant tissue.

NUMBER OF INSTARS.

The nymph passes through five nymphal stages, each stage differing from the others somewhat, both in structural detail and color.

LENGTH OF THE STAGES.

The length of the various stages was difficult to determine, due to the difficulty in rearing the insects. The work accomplished during the summer of 1921 was of little value. It was started with nymphs of the third, fourth and fifth instars. These were brought into the laboratory on large cuttings of host plants, which were placed in water and covered by lamp chimneys. The intention was to change the spittle insects to fresh plants as quickly as the original ones wilted. Apparently there was not enough plant juice to supply the amount of fluid for so many new masses of spittle necessitated by the changes. A few nymphs, however, were carried through to adults. In the spring of 1922, having obtained the very small first

instars, and using a different method of rearing, better results were obtained. Various host plants were planted in small flower pots, and the insects were confined on these under lamp chimneys. This was an improvement over the first method, although not entirely satisfactory. By having the living plant a more steady flow of sap could be obtained, so that the insect, once established was able to proceed without interruptions. The chief difficulties to cope with were in getting the very restless first instars settled, and the fact that the plants became stunted and sickly under glass chimneys. Wire cages would have been more satisfactory for the rearing of the later nymphal stages, but would have been too open for the first instar. From some fifty-odd groups of experiments, only seven first-instar nymphs were carried through to adults. Other reliable data for the various stages were obtained piecemeal by counting the length of time from molt to molt. The rearings were carried on on a back porch, so that the temperature was practically the same as in the field.

First-instar nymphs taken in the field remained the following number of days in this stage:

April 29 to May 5	7 days	May 12 to May 21	9 days
May 2 to May 9	7 days	May 12 to May 19	7 days
May 3 to May 10	7 days	May 12 to May 20	8 days
May 4 to May 14	10 days	May 12 to May 21	9 days
May 6 to May 17	11 days	May 12 to May 14	2 days
May 12 to May 17	5 days	May 11 to May 21	10 days

This gives a range of from two to thirteen days for the instar. However, these data are not sufficiently accurate, since the nymphs were not obtained directly from the egg, but were picked up promiscuously in the field. Some of them appeared to have just hatched. The average time is probably ten or eleven days.

Records for the second instar are as follows:

May 17 to May 25	8 days	May 21 to May 27	6 days
May 17 to May 22	5 days	May 25 to June 3	9 days
May 21 to May 27	6 days	May 22 to May 24	2 days
May 19 to May 25	6 days	May 22 to May 27	5 days
May 19 to May 26	7 days	May 22 to May 28	6 days
May 21 to May 29	8 days	May 24 to May 31	7 days
May 14 to May 21	7 days	June 26 to June 30	4 days

These are accurate counts taken from molt to molt. The range is from two to nine days and the average length seems to be six or seven days.

Third-instar nymphs lived from—

May 25 to May 31.......... 6 days	June 3 to June 9.......... 6 days
May 22 to May 29.......... 7 days	May 24 to June 5..........12 days
May 27 to June 6..........10 days	May 28 to June 8..........11 days
May 25 to June 1.......... 7 days	May 31 to June 13..........13 days
May 26 to June 3.......... 8 days	May 27 to June 4.......... 8 days
May 29 to June 6.......... 8 days	June 30 to July 6.......... 6 days
May 21 to May 30.......... 9 days	

These are also counted from molt to molt. The range is from six to thirteen. The average is eight.

The fourth stage lasted from—

May 31 to June 8.......... 8 days	June 5 to June 14.......... 9 days
June 6 to July 1..........25 days	June 13 to July 7..........24 days
June 1 to June 11..........10 days	May 31 to June 12..........12 days
June 3 to June 12.......... 9 days	June 5 to June 13 .... 8 days
June 6 to June 16..........10 days	June 6 to June 13.......... 7 days
May 30 to June 9..........10 days	June 8 to June 14.......... 6 days
June 9 to June 18.......... 9 days	June 1 to June 25..........24 days

The range is from six to twenty-five and the average is between nine and ten.

The fifth stage lasted from—

June 8 to June 19..........11 days	June 18 to June 29..........11 days
June 1 to July 15..........14 days	June 14 to June 24..........10 days
June 11 to June 26..........15 days	July 7 to July 20..........13 days
June 12 to June 28..........16 days	June 12 to June 30..........18 days
June 16 to July 8..........22 days	June 14 to June 25..........11 days
June 9 to June 23..........14 days	June 25 to July 9..........14 days

The range is from ten to twenty-two and the average between eleven and fifteen.

The seven complete histories from first instar to adult are as follows:

Number.	First.	Second.	Third.	Fourth.	Fifth.	Totals.
1......................	11	8	6	8	11	44
2......................	9	6	10	25	14	89
3......................	7	6	7	10	15	45
4......................	7	7	8	9	16	47
5......................	9	8	8	10	22	57
6......................	2	7	6	10	14	39
7......................	13	9	6	9	11	48

From the foregoing data it is apparent that there is a wide variation in the length of any stage, which is probably due to the nature and condition of the food plant and the abundance of the sap.

Field observations also show a wide variation in the length of the stages. In 1922 the first-instar nymphs were taken on April 29 and

the last one on June 23, while they reached their maximum abundance between May 11 and May 16. Second-instar nymphs appeared May 4, reached their maximum number about May 18 to May 27, and disappeared around June 20. Third instars were first taken about May 11, were most abundant from May 29 to June 3, while fourth instars appeared about May 16 and reached the maximum from June 7 to June 10. The first fifth instars were taken on June 2. They were most abundant from June 13 to June 20 and began to thin out by June 27, the last two being taken on July 4. The average total of days for the nymphal stages is perhaps forty-five days.

HABITS OF NYMPHS.

Perhaps the first thing of interest to note about the nymphs is their restlessness in the laboratory and their agility in moving around. Since they are always found in spittle masses, it is only natural to think of them as being rather inactive, helpless larvæ, but such does not appear to be the case. The first-instar nymphs especially are most active. In fact one of the greatest difficulties to overcome in the rearing of these insects was the continual moving of the first instars. When collecting, if the larvæ were brought away undisturbed in their spittle masses they usually were found missing on arriving at the laboratory. A satisfactory method of taking them is to wrap the plants in an improvised envelope of newspaper and carry them away in this fashion. When the nymphs are transferred to new plants it takes them some time to become settled. They ramble aimlessly over the plant, seemingly looking for the most favorable feeding ground. In one instance a nymph was observed which wandered the entire length of the stem and back again, then out on the leaf, where it rambled all over the surface, and even hung poised in the air, walking on the extreme margin of the leaf. During this wandering period they repeatedly fall off the plant on the dirt, where, if they happen to light on their backs, they struggle to regain their feet, and usually perish in the attempt. They dry up very quickly if not living in their spittle masses. Many times they crawl from the plant to the ground and reach the surface of the glass globe, where ensues a struggle to climb up the slick glass. Several times during their wanderings the first instars have disappeared entirely, crawling through two thicknesses of cheesecloth.

This restlessness of the nymphs is apt to be incited in two ways, namely, by disturbing them in the spittle mass and because of lack of juice from the plant. While looking for molted skins it was

usually necessary to shove the insect around in the spittle mass in order to see the skin, and this often disturbed the nymph so much that it would immediately hunt a new place.

Lepyronia nymphs have a comical appearance while walking over the plant. Their legs are long and they walk with their bodies lifted high in the air. Sometimes they walk exceedingly fast, but at other times they merely creep along. Occasionally the nymph extends its abdomen in the air at right angles to its body, first expanding it and then contracting it in a telescopic manner; it does this even while it walks.

The gregariousness of spittle insects is plainly evident, although it probably is due more to chance than instinct. A probable explanation is that in their roaming over the plants they encounter other spittle masses, and it is much easier to stay in this than to make a new mass. In many cases three or four instars have been found together in the same spittle mass. For this reason, toward the last of the season the first instars are not so readily seen unless each spittle mass is examined, since they are found deeply imbedded in the spittle mass made by larger nymphs. On one stalk of *Ambrosia trifida* (horseweed) three inches of solid spittle were found extending all around the stem. In the mass there were thirty-one insects, of which sixteen were fourth instars, ten were third instars, and five were fifth instars. Fifteen molted skins were found in it also. On another plant were found three large masses of fourth and fifth instars, which were packed so closely together that the spittle scarcely covered them. Spittle masses were very large and abundant on elm sprouts; one stalk bore a mass of spittle which extended four inches along the stem; another branch bore eleven masses. On another host plant two large masses of spittle were found, one mass containing six nymphs and the other six or ten. On June 13, on a single plant of *Ambrosia trifida* a spittle mass twelve inches long was found, which contained sixty-eight or more nymphs. The spittle was white and foamy, but was barely enough to cover the nymphs, since the form of their bodies could be plainly seen through it.

In the literature it is often stated that the nymph lives and molts in the same mass of spittle until the adult form is reached. Comstock (1895), in his brief discussion of Cercopidæ, states that it had been asserted that they undergo all their changes in the spittle mass. Girault (1904) says of *Aphrophora parallela* (Say), that they seldom move unless disturbed, and Garman (1921), in his work with *Phil-*

ænus lineatus (Linn.), states that during nymphal life the bug may construct several balls, but that there usually is little migration after the first mass is formed. Kershaw (1914), on the other hand, is of the opinion that the nymphs of *Tomaspis saccharina* usually, but not always, leave the spittle mass after a molt.

In the study of *Lepyronia quadrangularis* an experiment was attempted to determine just to what extent these migrations were carried on in the field. Four goldenrod plants bearing spittle masses were marked with white rags about May 12. It was difficult to determine in what stage the nymphs were at this time, since it was not thought best to disturb them, but they appeared to be in the latter part of the first stage. On May 16 three plants had second instars on them and the fourth had a second- and a fourth-stage nymph in one mass. On May 27 these plants were observed again. One plant was entirely deserted, but the other three appeared to be all right, with the spittle masses in practically the same position. June 2 found them practically the same, but other weeds were beginning to crowd around them so that little data thenceforth could be obtained. On June 7, however, one or two new masses of spittle were found on each of the marked plants, including the deserted one, which now bore three masses. This seems to point to the conclusion that the nymphs do move in the field even when not disturbed. Frequently, while collecting, molted skins can be found in deserted spittle masses.

In captivity, at least, as was stated above, the nymphs move considerably. Following the records of a few reared from first instars to adults may illustrate this fact. One first instar collected on May 6 was placed on a plant and soon formed a spittle mass. On May 17 it molted to a second instar, remaining in the same mass of spittle until May 18. On this date it moved farther down on the plant and made a new mass. It remained in this mass of spittle until June 7, in the meantime having molted on May 23 and May 25. After this last migration it formed a new mass of spittle higher up on the plant, where it remained until emerging as an adult. Another nymph, collected on May 12 and reared to adult, moved only twice, both times being between molts and not just after. Still another moved three times during its five changes. A fourth specimen, collected in the second stage, moved six times before emerging as an adult, and only once moved directly after molting. From the foregoing there appears to be no fixed habit of moving after each molt.

They probably move from lack of food or because of disturbances, and in the field, if they find a favorable place, they may stay in one place throughout their period of growth.

The size of the spittle mass varies for each instar, being in proportion to the size of the nymphs. The first-instar nymphs, at least the recently hatched ones, are covered by a clear drop of fluid with very little foam, and for this reason are easily discovered in the field. In fact, they were originally discovered by means of these clear drops of fluid. When walking through the weeds the writer's attention was attracted by these shiny drops of fluid on the vegetation, and upon closer examination it was found that they came from the spittle nymphs, which were usually found on the under sides of the leaves, and for this reason are not easily seen. The spittle masses of the other instars are usually foamy and puffy in the field.

When the insect is ready to transform into an adult an interesting change in the spittle mass takes place. The superficial part of the foam dries and stiffens somewhat, so that it forms a roof to a closed chamber. Within this chamber the molt occurs, and the adult can be seen distinctly in this mass. It usually takes a day for the adult to harden sufficiently to emerge. If they are removed from the mass too soon they do not gain their full color, but have a yellowish-tan appearance. When the adult is ready to emerge the slightest disturbance causes it to give a strong leap, thus freeing itself from the spittle ball and leaving a round opening in the latter. Empty chambers are found quite frequently in the field.

In captivity all the instars made comparatively little spittle. In a good many cases they lived chiefly in the fluid without producing many bubbles. When the spittle was produced it usually was just sufficient to cover them. The fourth- and fifth-instar nymphs were able to make the most spittle, but even these did not reach the proportion of those in the field.

The process of froth-making in the Cercopidæ has been a topic of discussion for some time. The earliest conception of the spittle masses was that they were voided by tree frogs. Fabre (1900), in the discussion of froth-making by *Aphrophora spumarius*, which in his picturesque way he calls the "cicadelle," says that the peasants of France give another name to this substance. They call it "cuckoo spit," because the little balls occur at the time of year when this bird returns from its migrations. The early entomologists assigned the spittle to its correct cause, but they thought that the foam

was exuded from the anus of the little nymphs. This viewpoint was summarized by Harris (1862) as follows: "Here may be arranged the singular insects called froghoppers, Cercopidæ, which pass their whole lives on plants, on the stems of which their eggs are laid in the autumn. The following summer they are hatched and the young immediately perforate the bark with their beaks and begin to imbibe the sap. They take in such quantities of this that it oozes out of their bodies continually in the form of little bubbles, which soon completely cover up the insects."

In 1900 several papers on froth formation were published by European and American writers. Morse (1900) is generally given the credit for discovering that the insect emits a liquid only and later enfolds air bubbles in the liquid. His original account really appeared in 1875 in his "Elementary Zoölogy." Fabre (1900), Gruner (1900), and Sulc (1900) concluded the same thing, but they all differ as to the method by which the result is obtained.

According to Morse (1900) a clear fluid is emitted by the nymph, which flows over the entire body and fills up the crevices between the legs. Next the insect extends the abdomen out of the fluid, opens the posterior segments like claspers, grasps a bubble of air, and then turns the abdomen under the fluid, allowing the inclosed air to escape. According to him, the movements go on at the rate of seventy to eighty times a minute and thirty to forty bubbles were made in a half hour. He says that the claspers seem to be the tergal portions of the ninth segment.

Fabre (1900) describes a similar apparatus. According to him, the insect has a special device, which is composed of the two pleural lobes of the ninth segment, acting as claspers for grasping air, and a pocket, formed by these lobes, which serves as a container for air. From a caudal view of the abdomen, when the two pleural lobes are drawn apart, a y-shaped opening in the pocket is produced, or, in other words, the expanding and contracting of these lobes opens and closes the pocket. In producing the bubbles the tip of the abdomen is thrust out of the liquid, the pleural lobes spread apart, letting air into the pocket, then close together again, and at the same time the abdomen is pulled under the fluid. At this point the pocket, being flexible, contracts, and thus forces air out of the pocket, forming a bubble in the viscid fluid.

The explanation of bubble formation advanced by Gruner (1900) is similar to that of Fabre's in that he too describes a pocketlike cavity and two terminal clasping plates. He maintains, however,

that the air for the bubbles is supplied from the tracheæ. The following is his account of the process: "Soon after the larvæ have fastened themselves head downward on the plant and have imbibed some of the sap, the terminal portion of the abdomen rythmically contracts so that the fluid from the anus is exuded and flows into the cavity or pocket. The insect being head downward, the fluid flows into the pocket, where it becomes mixed with air coming from the last few pairs of spiracles. Bubbles are thus produced in the pocket by the contraction and expansion of the tergal plates."

Sulc (1910) describes a still different apparatus, namely the air canal. He says that the "pochette" of Fabre and the "tasche" of Gruner is not present, but that the special device is the air canal (pl. LXII, figs. 6 and 7). This air canal or channel is formed by the tergal pads or plates. Beginning with the fourth segment and extending to the ninth, the plates are prominent and are capable of touching on their median margins. The plates of the first and second segments are short and widely separated from each other The tergal plates of the third abdominal segment are triangular, so that only their posterior medial margins can touch each other. Arising from the median portion of the third sternite between the two plates there appears a special triangular, caudad-projecting protuberance (pl. LXII, fig. 6), which serves to close the channel. Thus the tergal plates form a channel which extends directly from the ninth segment to the middle of the third. At this point it becomes Y-shaped, dividing into two smaller channels, which continue to the right and left until the hind margins of the thorax are reached. When the cercopid is submerged in the spittle the tergal pads are pressed firmly together by means of the contraction of strong muscles, and the tip of the abdomen just reaches the surface of the spittle. According to Sulc, the froghopper nymph can be compared to water-dwelling insects with open, tracheal systems, only deviating from all hitherto known examples by having this special device of the air channel. When fresh air is desired the tip of the abdomen is thrust out of the spittle, the air channel opens and the air enters. Immediately the air channel is compressed and at this moment a bubble is released in the spittle mass.

The writer's own observations were made before reading the above descriptions. It was very difficult to view this process at all, because of the difficulty of getting the nymphs to settle on the cut plants, and when they made the foam on living plants it was almost impossible to focus the microscope on them. Most of the observa-

tions were interrupted before much data could be obtained. The longest observation was that on a fourth instar, which started making spittle on a large leaf which could easily be placed under the microscope. It started making spittle at 9:40 a. m. At this time the abdomen was extended in the air, and from the slitlike opening in the anus could be seen to exude a clear fluid, which flowed down beneath the body in the ventral channel or air canal of Sulc. A second or so was spent in ejecting this fluid, and then the insect began dipping the abdomen in and out of this fluid, each time producing a bubble. It did this for ten times, and then the abdomen was lifted high in the air twice and the terminal plates were spread far apart. When a number of bubbles was produced the abdomen was pulled beneath them and then brought up through them so that they were separated and pushed on each side of it. When reaching after air the plates were spread far apart, but at the surface of the spittle they came together. The farther out the abdomen was extended and the slower the movements the larger the bubbles were. The abdomen was next pulled down deeply in the spittle and a few small bubbles were produced. Again the nymph rested for a minute or so, while more fluid flowed from the anus At times the nymph kicked rapidly with its two front pair of legs, making the bubbles go to the side, and during the whole performance one front leg was constantly kicking so that gradually the bubbles were worked headward. Again it made bubbles, rested for three and one-half minutes, while the body was straightened out until the spittle was all around the side and partly on the side of the head. Another cessation of bubble-making lasted for six minutes. Later the nymph lay almost on one side with the bubbles entirely on the other side. Next more fluid was ejected until the body was entirely surrounded and the bubbles pushed entirely to the edge of the fluid mass. A rest of ten minutes followed. At 11:10 it had not ceased making spittle, and the insect was still visible, although the entire body was covered by a thin sheet of foam. At 11:45 there was considerable more spittle and the nymph was still working.

Another nymph was watched. It started making spittle at 8:20, and in fifteen minutes had enough spittle to make a thin covering for its body.

From a study of the nymphs of *Lepyronia* it appears that Sulc has described the process more accurately than any of the others. His description seems to differ only in extent from that of Fabre and Morse, both of which consider the two tergal plates of the ninth

segment of the abdomen as being the responsible machinery. Since these are the terminal plates, they naturally are the most prominent and under low magnification appear to do most of the work. From a translation of Sulc's work, it seems that he does not attribute the bubbles to the work of merely the last pair of plates, but to all nine pairs, which come together and form the air channel. He thus makes respiration and bubble-formation a simultaneous action. From observations of *Lepyronia* he is apparently right, since the writer has seen six pairs of plates in action very distinctly.

COMPOSITION OF THE FROTH.

The composition of the froth of spittle insects has been studied by different writers. They all have noted the viscid quality of the fluid, which they assert is necessary to maintain the frothy condition. Morse (1900) found that when nymphs were placed in water they immediately began clutching the air and making bubbles. The bubbles disappeared, however, as soon as made, for the clear water did not preserve them. Besides this viscidity, the spittle has a certain insolubility in water and alcohol. When collecting immediately after showers and heavy rains the spittle masses are found intact, even those which were in exposed places. In alcohol the spittle seems to coagulate in a stringy mass, which clings to the feet and body and is hard to pull away. Garman (1921) says that it is readily soluble in sodium hydroxide, has no reaction to iodine, although probably containing some sugar, and that the albuminous substance is not coagulated with heat. Gruner (1900) after several experiments comes to the conclusion that 94.565 per cent of the spittle fluid is water, 3.827 per cent organic substance, and 1.607 per cent inorganic salts. The spittle mass of *Lepyronia* can easily be told in the field from that of a *Clastoptera* by its composition. The spittle of the former contains more and larger bubbles and resembles the beaten white of egg, while the spittle of *Clastoptera* contains much smaller bubbles, which seem to be all on the outside of the mass, while the center of the mass appears to be a clear, gelatinous material. Kershaw (1914) states that the spittle of the nymph appears to be a mucin or mucinoid. He found that it granulates with subacetate of lead and stains deeply with methylene blue in glycerin and alcohol. Furthermore, the fluid appears to have every substance excreted from the anus, such as calcium oxalate, uric acid, leucine pellates and urates, potassium and sodium chlorides.

LONGEVITY OF ADULTS.

In 1921 the first adults were collected June 14 and the last ones on July 23. The latter date does not represent their last appearance, but merely the time when collecting trips ceased. In the spring of 1923 Mr. C. H. Curran collected specimens on April 1 and April 4, which was practically the first indication that they might overwinter as adults. By the first part of May adults were no more in evidence. Adults hatching from eggs in the spring began to appear on June 13, becoming quite numerous by June 19. The rest of the summer and fall adults could be taken in great numbers, sometimes averaging seventy-five in one hour's collecting. The last date in the fall was November 23. In the spring of 1923 adult females were first taken on April 19. From these facts it appears that the insects, at least the female, spends the greater part of the year in the adult form—from the middle of June until about the middle of April, or a period of ten months.

HABITS OF ADULTS.

The adult bug is a very sluggish insect. It sits for hours on the stems and leaves of plants, feeding continually. Many were found on thistle plants, where they could be easily watched. Some were under observation for two hours, during which time they never changed position. While feeding they emit a clear fluid or honey dew, which falls from beneath them in large drops. One individual was watched for an hour, during which time 200 drops of honeydew were emitted. While feeding they usually sit with their legs folded snugly beneath the wings. When walking they seem to spread the two front pairs of legs out to the side, propelling themselves along by them, but the hind pair are held straight beneath the wings and dragged along behind, evidently only of use in jumping. When disturbed froghoppers give a powerful leap, and for this reason are hard to collect. The best method of collecting them is by sweeping and then holding a large-sized test-tube in front of them in such a position that they will hop into the tube, since they always jump in a forward direction.

MATING.

Mating takes place in the late fall. On September 27 two pairs were found mating in a cage in the insectary. On September 28 one pair was caught in the field while mating and two pairs in an inside cage. A day later two more pairs mated, and on September 30 another pair and on October 2 still another, making nine pairs in all. After this the males probably die and the females go into winter quarters.

FOOD HABITS.

The nymphs and adults of this cercopid have a wide range of food plants. The nymphs have been found feeding on sixty-two species of plants, which are as follows:

Actinomeris alternifolia	Compositæ.
Agrimonia gyrposepala (agrimony)	Rosaceæ.
Ambrosia trifida (horseweed)	Compositæ.
Ambrosia artemisiifolia (ragweed)	Compositæ.
Andropogan furcatus	Gramineæ.
Apocynum cannabinum (dogbane)	Apocynaceæ.
Apocynum pubescens	Apocynaceæ.
Asclepias syriaca (common milkweed)	Asclepiadaceæ.
Asclepias tuberosa (butterfly weed)	Asclepiadaceæ.
Asclepias verticillata	Asclepiadaceæ.
Aster paniculatum	Compositæ.
Aster salicifolius	Compositæ.
Bromus secalinus (chess or cheat)	Gramineæ.
Chenopodium album (lamb's-quarters)	Chenopodiaceæ.
Cirsium altissimum (thistle)	Compositæ.
Cornus baileyi (dogwood)	Cornaceæ.
Erigeron canadensis (butterweed)	Compositæ.
Erigeron ramosus (daisy fleabane)	Compositæ.
Eupatorium altissimum	Compositæ.
Galium aparine var. vaillántii (cleavers)	Rubiaceæ.
Geum canadense (avens)	Rosaceæ.
Geum strictum (avens)	Rosaceæ.
Helianthus grosserratus (?) (sunflower)	Compositæ
Helianthus petiolaris	Compositæ
Heliopsis scabra (oxeye)	Compositæ.
Juglans nigra (black walnut)	Juglandaceæ.
Lactuca canadensis (wild lettuce)	Compositæ.
Lactuca pulchella (?)	Compositæ.
Lactuca scariola	Compositæ.
Lactuca spicata	Compositæ.
Lycopus americanus (?) (water horehound)	Labiatæ.
Melilotus alba (sweet-clover)	Leguminosæ.
Morus rubra (red mulberry)	Urticaceæ.
Osmorhiza claytoni (sweet cicely)	Umbelliferæ.
Panicum virgatum	Gramineæ.
Panicum wilcoxianum	Gramineæ.
Phleum pratense (timothy)	Gramineæ.
Plantago rugelii (plantain)	Plantaginaceæ.
Prunella vulgaris (heal-all or carpenter weed)	Labiatæ.
Rhus glabra (smooth sumac)	Anacardiaceæ.
Robinia pseudo-acacia (black locust)	Leguminosæ.
Rosa setigera (wild rose)	Rosaceæ.
Rubus canadensis	Rosaceæ.
Rubus occidentalis (black raspberry)	Rosaceæ.

Rudbeckia fulgida (coneflower)	Compositæ.
Ruellia ciliosa	Acanthaceæ.
Ruellia parviflora	Acanthaceæ.
Sanicula canadense	Umbelliferæ.
Sanicula marilandica (black snakeroot)	Umbelliferæ.
Solidago altissima (goldenrod)	Compositæ.
Solidago rigida	Compositæ.
Sphenopholis obtusata	Gramineæ.
Stachys palustris (hedge nettle)	Labiatæ.
Symphoricarpos orbiculatus (coralberry)	Caprifoliaceæ.
Taraxacum officinale (dandelion)	Compositæ.
Triadenum virginicum (marsh St. John's wort)	Hypericaceæ
Tridens flavus (tall redtop grass)	Gramineæ.
Triticum vulgare (wheat)	Gramineæ.
Ulmus fulva (slippery elm)	Urticaceæ.
Urtica gracilis	Urticaceæ.
Verbena urticaefolia	Verbenaceæ.
Vernonia baldwini (ironweed)	Compositæ.

Among this list of plants there are nineteen families of plants represented. The families containing the most species are the Compositæ, Gramineæ and Rosaceæ, which have twenty, nine and five species, respectively. In early spring the first nymphs were found in one small plot of *Solidago* plants. Later they were found on other groups of plants, such as aster, grasses and giant horseweed (*Ambrosia trifida*). Toward the last part of the nymphal season the most popular single food plant, perhaps, was *Ambrosia artemsiifolia*, or ragweed. It was chiefly on *Ambrosia trifida* and *Cirsium altissimum*, however, that the large masses of spittle containing so many nymphs were found.

The spittle masses are usually found along the plant stems, although with broad-leafed varieties of plants, such as plantain and elm, they are also found on the back of the leaves.

Not only did the nymphs collectively show a remarkable diversity of choice of food plants, but each individual nymph seems to have no restriction to any particular plant. Nymphs feeding on thistle in the field could be brought into the laboratory and reared on ragweed. In the cages where several species of plants were growing together, such as ragweed and lamb's-quarters, nymphs have been observed to migrate from one to another several times during their development.

Fabre (1900) discusses this strange disregard, as he calls it, of genera and species of plants. He says that it would be hard to make a list of the plants in his neighborhood which have been lacking in spittle. With a brush he picked up nymphs feeding on one

species of plant and deposited them on a new plant of entirely different flavor, only to find that the new was accepted without hesitation. He found that the insect could easily be transferred from the bean, a plant of mild flavor, to the spicy euphorbia, and back again. It also could be transferred from such pepper plants as *Arum italicum,* of which it takes only a small portion of the leaf to burn the lips, to the perfumed marum and common dandelion. In order to find the explanation of this Fabre carried on the following experiments. He first discovered that when he punctured a euphorbia plant with a small instrument, the milky, poisonous sap oozed forth, but that when the beak of the insect was pushed in only a colorless, neutral fluid was obtained. In fact, the nymph soon perished in the milk of the euphorbia, because of its caustic properties. He therefore concludes that the siphon of the cicada, by a selection which should be envied, selects at the bottom of the puncture the substance it needs for food, which is the same in all plants, and therefore produces the same colorless fluid, no matter what the species of plant is on which the nymph is feeding

Other observers have found this species feeding on additional host plants. Gillette and Baker (1895) took it on *Clematis ligusticifolia* and *Carex* (Gillette). Lintner (1895) found it very common in groves of sugar maple, "where numbers of them were often met with, drowned in vessels of sap." Osborn (1916) took it on *Impatiens biflora*.

NATURAL ENEMIES.

It is generally conceded that the froth or spittle is a protective measure. This is undoubtedly the case, for cercopid nymphs are remarkably free from parasites or predators. A *Syrphus knabi* was found sucking at a spittle mass for a short while, but soon flew away without causing any disturbance. At one time a nabid nymph was found sucking the nymph of *Clastoptera proteus*. The latter was found about two inches away from the nearest spittle mass, and probably had just left the mass when it was captured by the nabid nymph. Three adults of this same species of cercopid were found in the web of a small spider. They were all dead. Gruner (1900) experimented with red ants and the nymphs of *Aphrophora* and *Philænus*. If he placed the nymphs, without any spittle, near the ants, the latter immediately pounced on them and began dragging them away. However, when he placed grass tufts, bearing nymphs in spittle masses, near them, the ants immediately covered the tufts,

but as soon as the mass was reached would stop and turn back. Garman (1921) states that the spittle ball offers an ideal medium for molds and bacteria, which may sometimes be found in large numbers. None of these organisms were found in the spittle balls of *Lepyronia*. Urich (1913) in his studies of Trinidad froghoppers has found that they are preyed upon by two birds, a reptile, batrachian, spiders, predatory insects, and is the host of two parasitic insects and a parasitic worm, which all together play an important part in the control of these froghoppers. Williams (1923) reports the larvæ of *Drosophila paradoxa* living in the spittle mass of a *Clastoptera*. He states that they undoubtedly kill some of the spittle nymphs. Considering the family as a whole, however, it is evident that froghoppers have few natural enemies, and this probably is due to the protection of the viscid spittle material.

DESCRIPTION OF DIFFERENT STAGES

THE EGG.

Length, 1.2 mm.; width, 0.3 mm. Elongate, slightly curved, tapering to a rather sharp point at one end and to a more blunt one at the other end. They are white in color, somewhat transparent, and the surface is smooth.

FIRST INSTAR.

Size. Average length, 1.53 mm; width across eyes, 0.456 mm.; width across abdomen, 0.549 mm.

Color. Head and thorax yellowish white washed with brown, the mesothorax and metathorax darker gray-brown. The abdomen is a bright yellow, with a pair of oval, orange spots occupying the lateral and part of the dorsal and ventral surfaces of the fourth, fifth and sixth segments. The eyes are reddish brown and the legs yellowish white washed in brown, especially at their bases.

Structural characteristics. The anterior portion of the head is bulblike, distinctly rounded and with the clypeus greatly inflated. The division between the front and vertex is indicated by a short line cephalad of each antenna, which runs mesad. No ocelli are present. The antennæ have nine segments, the basal segment a short, stout one, the second and third elongate-stout, and the fourth fan-shaped, with the distal five segments ringlike. There is no evidence of wing pads from a dorsal view, and only a faint indication from the lateral view in the form of a slight caudal extension. The legs have proportionately greatly elongated coxæ and have only two segments in the tarsus, a short basal one and a longer distal one. Pleural lobes are not conspicuous.

SECOND INSTAR.

Size. Average length, 2.02 mm.; width across eyes, 0.525 mm.; width across abdomen, 0.699 mm.

Color. Body is pale yellowish-white. Head is washed in reddish-brown. Prothorax is pale yellowish-white only slightly washed in grayish-brown. Mesothorax and metathorax are darker gray-brown. Orange spots on abdomen are only faintly visible.

Structural characteristics. Practically the same as in the preceding instar The wing pads show no marked development. The mesothorax and metathorax together are equal in length to the prothorax. Clypeus is slightly more inflated than in the first instar.

THIRD INSTAR.

Size. Average length, 3.75 mm.; width across eyes, 1.05 mm.; width across abdomen, 1.33 mm.

Color. Body is pale whitish-yellow, with considerable more yellow than in the second instar. Head and thorax are unchanged in color.

Structural characteristics. The wing pads are plainly visible as caudal extensions of the lateral angle of the thoracic tergites, the first pair more prominent than the second. The mesothorax is equal in length to the prothorax and about twice the length of the metathorax. Two ocelli are present and are black in color. Antennæ with nine segments, but the terminal five segments are much elongated.

FOURTH INSTAR.

Size. Average length, 4.48 mm.; width across eyes, 2.57 mm ; width across abdomen, 2.17 mm.

Color. Body pale greenish yellow. Head washed with reddish brown. Thorax varies from pale yellow to dark brown on mesothorax and metathorax.

Structural characteristics. Antennæ are practically the same in shape, but more elongate. The first pair of wing pads are produced caudad until their apices almost reach the apex of the second pair. The exposed portion of the second pair is but little longer than that of the first pair.

FIFTH INSTAR.

Size. Average length, 6.94 mm ; width across eyes, 2.57 mm.; width across abdomen, 2.17 mm.

Color. Body whitish green with very little yellow. Head and thorax are generally of the same color as the body.

Structural characteristics. Lateral angles of the first pair of wing pads are more produced and as long as the second pair. Second pair are also greatly enlarged both in width and length, reaching the third segment of the abdomen. Prothorax has the adult form with its emarginate posterior margin. Median portion of mesothorax, is produced caudad until it almost touches the posterior margin of the metathorax. Metathorax also slightly produced caudad. On the metathoracic leg indication of the third tarsal segment is shown; the two rows of spines on the distal end of the tibia are also present, and the rows of spines on the distal end of each segment of the tarsus are faintly visible. The two front pairs of legs still have two segments in the tarsi and have two rows of spines on the distal end of the tibiæ which are not present in the adult.

NOTES ON THE DIFFERENT STAGES.

Structural differences between the first and second instars were hard to discover. The chief difference is in the size, although a few minor characters are sometimes evident. In the second instar the apex of the labium just comes to the first coxa, but in the first instar it extends to the second coxa, or at least between the coxæ

of the first pair of legs. In the second instar the length of the mesothorax and metathorax together is approximately equal to that of the prothorax, while in the first stage the prothorax is longer than the other two together and the mesothorax is slightly longer than the metathorax.

From the second to fifth instars color variation in the head and thorax can be found. Some specimens in each instar were both collected and reared in which the head and thorax were of the same color as the body. Others had head and thorax both washed in dark reddish brown, while still others had a pale prothorax with a dark mesothorax and metathorax, so that the thorax appeared to be distinctly banded. In the third and fourth instars the bands were of such dark-brown pigment that they appeared as black bands to the naked eye and made the nymphs very conspicuous. Apparently this color variation has no relation to sex, since both sexes have been found to have these different combinations.

On the fourth, fifth and sixth abdominal segments of the first instar appear two large, oval, orange spots. These spots make the first-instar nymphs more conspicuous and more vividly colored than any of the other instars. They probably indicate the location of the spittle glands which secrete part at least of the viscid fluid of the foam. Garman (1921) says that they appear as yellow spots on the side of the abdomen of *Philænus*, and Osborne (1916) found them as black spots in another species. Both writers state that the glands are found on the seventh and eighth segments, but in *Lepyronia* they are found on the above-mentioned segments. On the other hand, Kershaw (1914) says that the fluid is produced by the anterior or smooth portion of the malpighian tubes. The whole question is an interesting matter for further investigation.

ECONOMIC IMPORTANCE.

In general froghoppers are not considered economically important, since they are found feeding chiefly on weeds and wild plants. There are a few, however, which have been reported as doing considerable damage to certain cultivated host plants. Osborne (1916) thinks that the damage caused by froghoppers has been overlooked. According to him, *Philænus spumarius* L. considerably affects clover, for he noticed that the plants which are attacked wither and do not bear heads. He also has observed *Philænus lineatus* L. being so abundant on grass and hay crops as to occasion distinct losses, timothy and redtop being most frequently injured.

Ashley (1919) reports an *Aphrophora* in England which causes serious damage to roses during June and July by weakening the young shoots and buds by extracting the sap. Harris (1862) reports *Clastoptera proteus* as doing great injury to the cranberry crop in some parts of Massachusetts. The most destructive froghopper is the sugar-cane froghopper, *Tomaspis varia* Fabr., which is estimated by Urich (1913) as destroying ten per cent of the sugar crop of Trinidad. The damage which is done is called "blight" and consists of a withering of the leaves of the canes and a stunting of the stem. This is accomplished chiefly by the nymphs feeding on the roots, although the feeding of the adults on the leaves of very young plants may also cause it. Williams (1923) reports *Clastoptera theobromæ* Wills as destroying the flowers of the cacao in Panama.

No records of serious damage caused by *Lepyronia quadrangularis* have been found. Fitch (1856) records it on grape. The writer has found it on several economic plants, such as timothy, black raspberry, wheat and sweet-clover. Most of these, excepting wheat, were isolated plants or small groups of them, and therefore were not of much importance. In the case of the wheat, however, the matter was more serious. A good many stalks of wheat were found bearing spittle masses. These occurred chiefly at one side of the field next to the weeds, bordering a woods, and evidently they had migrated from the weeds to the wheat. In all cases where the nymphs were feeding on the wheat the heads were half the size of the good heads. Nine good heads were averaged, and the number of kernels was thirty-four to a head. Eleven poor heads were averaged, and the number was only ten, which makes an approximate loss of 33 per cent. From these observations, as well as those on the life history, the following conclusions can be drawn: That the insects by sucking the plant juices really cause considerable damage to the host plant; and they may become a menace to certain cultivated crops by their ability to migrate from one plant to another, and because, unless disturbed, they are so free from parasites and predators, they may greatly increase in number.

EXTERNAL ANATOMY.

Apparently little work has been done on morphology within the family Cercopidæ. In no case throughout the literature available for study has a thorough investigation of the structure of the entire body been made. One paper on the alimentary canal of a cercopid by Kershaw (1914), one on the respiratory system of a nymph of the Aphrophorinæ by Sulc (1910), and one by Metcalf (1916) on the wing venation of Cercopidæ, are the most extensive works to be found. Other brief references to the morphology of the Cercopidæ were found in a number of articles dealing with the homologies of certain special parts of the body among the families of Homoptera, namely, Taylor (1918) on the thorax, Kershaw and Muir (1922) on the genitalia of both sexes, Crampton (1922) on the male genitalia, and Hansen (1890) on the appendages and spiracles. One other article on the structure of *Aphrophora spumaria* by J. O. Harper (Science Gossip, 1874) concludes the list, but is of little value morphologically.

THE HEAD.

The terminology used in the discussion of the head is based mainly on that of Comstock and Kochi (1902), Martlatt (1896), and Funkhouser (1917).

The deposition of chitin is fairly heavy and uniform throughout the exoskeleton of the head. In fact, both dorsal and ventral surfaces are hard and brittle making dissection very difficult without first boiling in KOH.

A dense prostrate pubescence, consisting of thin, grayish hairs, covers the entire surface of the head. This gives the appearance of a grayish bloom, which partly conceals the coloration of the insect.

The *head* of *Lepyronia quadrangularis* (Say) resembles the other Homoptera in most of the essential parts, although it resembles some more closely than others. Perhaps it is more nearly like the Cicadidæ and Cicadellidæ when such points as the position of the head in relation to the body and the shape and comparative size of the sclerites are considered. The protruding, enlarged sclerite with its striated borders, commonly called the front, of *Lepyronia* instantly reminds one of the larger, homologous sclerite in the cicada. Likewise the heads of both these insects lie in nearly the same plane as the body, which condition is seldom found in other Homoptera outside of the Cicadellidæ. In *Lepyronia quadrangularis*, however, a flattening of the head dorsoventrally has taken place, with the result

that the vertex and the front lie entirely on the dorsal surface and the remaining sclerites on the ventral surface. Thus the anterior margins of the front and vertex (pl. LV, fig. 1) have been pressed against the anterior margin of the clypeus, which together form the cephalic and lateral margins of the head. The head, as is shown in the figure, projects straight forward on a line with the body and the beak projects backward and lies between the coxæ when at rest.

In the literature the most commonly accepted homology of the sclerites of the head are as follows: On the ventral aspect the large protruding sclerite (pl. LVI, fig. 2) is called the front; the smaller sclerite attached to its posterior margin, the clypeus; and the smaller triangular sclerite fastened to the clypeus, the labrum. The entire dorsal portion of the head (pl. LVI, fig. 1) is usually designated as the vertex, although it consists of two sclerites. The larger of these occupies most of the entire surface with the exception of the broad invagination in the cephalomedial region, into which a small subrectangular sclerite, the tylus, is inserted. There seems to have been no attempt to homologize or account for the existence of the tylus, although it appears as a definite sclerite in the adult and is partially indicated in the later nymphal stages.

Partly because of the lack of explanation with regard to the tylus and partly because of the suggestion of other workers in other groups, an investigation with regard to a different homology of parts was attempted. Funkhouser (1917) states that the clypeus in the Membracidæ is determined by the location of the anterior arms of the tentorium, which fully accords with the view of Comstock and Kochi (1902), that the anterior arms of the tentorium arise as invaginations of the body wall between the clypeus and front. He also refers to Bentley's work (1900) on the *Cicada*, which was unpublished, wherein the latter shows that the large, protruding sclerite known as the frons is really the clypeus. Several other articles in support of this theory have been found. Marlatt (1896) calls the sclerite in question (pl. LVI, fig. 2) the clypeus; likewise Smith (1892). Bugnion and Popoff (1911) state: "One of the characteristics of the clypeus is that it serves for insertion, with its deep face, of the anterior bundles of the dilator of the pharynx. A clypeus cleared in balsam shows in all Hemiptera the linear insertion of the striated membrane (of the pharynx) and the two sides of transverse lines which correspond to the insertion of muscles. Among some species (*Cicada*) the transverse lines are indeed seen from the exterior and give a particular appearance to

the sclerite. Without a doubt the clypeus of which they speak is the frons of other writers.

According to these writers, then, a different nomenclature from the commonly accepted one for the sclerites of the head of the *Cicada* has been used. The same thing holds true for *Lepyronia quadrangularis*. The sclerites on the ventral surface of head would be labeled clypeus, labrum and epipharynx (pl. LVI, fig. 2). In figure 1, the vertex remains the same, but the tylus would be termed the front.

A study of the tentorium and the position of the ocelli bear out this homology for both the *Cicada* and *Lepyronia*. As was mentioned above, Comstock and Kochi (1902) showed that the ends of the suture between the front and clypeus extend to the invagination which forms the anterior arms of the tentorium. From this it follows necessarily that the position of the tentorium would undoubtedly prove the identity of the front and clypeus in these insects. The tentorium (pl. LVI, fig. 3) is of practically the same shape in the *Cicada* and in *Lepyronia*. It consists of a slender transverse bar, which is the basal part or body of the tentorium, from which two long, slender, chitinous arms extend cephalad, and two short, posterior arms extend laterad. In the *Cicada* the basal portion is fairly narrow, not extending over one-third of the width of the occipital foramen; it occupies a central position in the head cavity. The anterior arms are by far the longest part of the tentorium and can easily be seen to run almost directly cephalad and slightly laterad to the point which marks the cephalolateral angle of the large protruding sclerite or clypeus. The tentorium in *Lepyronia quadrangularis* varies somewhat from that of the *Cicada*, but is essentially the same. In the cercopid the basal part of the tentorium is more extensive, in that it occupies about two-thirds of the width of the occipital foramen. The anterior arms extend in much the same direction as the *Cicada*, but their extreme anterior portions have become somewhat modified, due, no doubt, to the peculiar compression of the head. At this point it would probably be clearer to follow the figure (pl. LVI, fig. 3). In this figure the head is in the exact position as in figure 1, with the exception that the vertex has been removed in order to show the tentorium. The vertex appears to be very loosely attached to the tylus, for it can readily be lifted away. After the vertex has been removed the connection of the tylus and clypeus can easily be seen. The anterolateral corners of the clypeus are reflexed and the cephalic

margin of the reflexed corner has become strongly fused to the lateral margins of the tylus. It is not strange that with the peculiar arrangement of these sclérites, as well as the compression of the head on the anterior portion, that the tentorium has assumed a peculiar position also. In the first place, the anterior portion of the forearm of the tentorium has become forked. The prongs are blunt at the end and are of unequal length. The smaller one is attached to the skeleton of the head at a point about midway on the clypeus (fig. 3) and just back of the antennal pit. If the tentorium stopped here it would indeed be hard to identify the clypeus, since it is equally as far from either of the anterior margins of the two sclerites in question. Even in that case it would seem more plausible that it should have migrated backward due to the flattening of the head, already described, than that it should have migrated so far forward for no accountable reason. Fortunately, however, the other branch of the fork extends farther cephalad. It curves slightly mesad, following the free margin of the reflexed clypeus, although not touching it. In fact, it extends as far forward as the corners of the clypeus at the point where the latter is attached to the latero-posterior angle of the tylus. The tip of the branch appears to be attached by a membrane to the ental surface of the vertex. The significance of the position of the tentorium at this place in the attempt to locate the front and clypeus seems to be this: If the reflexed corners of the clypeus were bent back in their normal position and the front and vertex were laid out on the plane of the rest of the head sclerites, then the anterior arm of the tentorium would extend to the laterocephalic margin of the sclerite labeled clypeus in figure 3. The sclerites of the head from this view could easily be designated in succession as the vertex, front, clypeus, labrum and epipharynx without any intervening unexplained tylus.

Another argument for such nomenclature is the position of the median ocellus and its relation to the frons. Referring again to Comstock and Kochi (1902), we find a statement to the effect that the frons, in the more generalized insects at least, bears the median ocellus. Funkhouser (1917) is of the opinion that in the Membracidæ the frons has disappeared and with it the median ocellus which it contained. While Crawford (1914), in his work with Psyllidæ, states that in all cases where the frons is present it bears the anterior ocellus at its base or at the end nearest the vertex. In the Cicadidæ the median ocellus is distinctly located on the dorsal surface of the head in the sclerite just above that which is

generally called the frons. In *Lepyronia quadrangularis* there is of course no median ocellus present, but if it were present it seems highly improbable that it would be located on the ventral aspect of the head, so far removed from the other two ocelli. Its position would be more likely the normal one at about the place where the tylus is located.

The *compound eyes* (pl. LVI, fig. 1) are large but not very distinct on the dorsal aspect, due to the fact that their dorsal surfaces are level with the vertex, and the color of both is somewhat the same. They are oblong in shape, broader at the anterior end and narrower towards the posterior. They are located in the extreme caudolateral angles of the head.

There are two *ocelli* (pl. LVI, fig. 1) present, located about midway between the front and the pronotum and about as far from each other as from the compound eyes.

The *antennæ* (pl. LV, fig. 2) are located on the ventral surface of the head in a hollow pit halfway between the eyes and the clypeus and slightly cephalad of the eyes. In general appearance they are small and inconspicuous, appearing to consist of a very short basal stump and a long, thin, hairlike part which extends some distance beyond the sides of the head. From specimens stained with eosin and mounted on slides, more details of structure could be observed. The basal segments, called collectively the *shaft* or *peduncle*, are three in number. The first of these is subcylindrical, about as wide as long, and is apparently the widest of the three. The second segment is likewise subcylindrical, but approximately twice as long as wide, with its basal end slightly narrowed and its broader distal end cup-shaped. The last of the segments of the peduncle is the shortest, oviform in shape, and fits into the concave end of the second segment by means of a little stalk. The *flagellum* or *whip* consists of many segments, the exact number of which it was difficult to determine. After the first twenty-nine segments, extending two-thirds of the entire length, the segmentation becomes indistinct. In general these segments are cylindrical, but vary somewhat in shape, being longer than wide toward the tip of the filament and about equal in length and width at the base. The sense organs of the antennæ are located at the base of the filament and at the tip of the third segment of the peduncle. They consist of a small group of sensory pits, averaging about eight in number, and generally located close to the apex and somewhat to one side of the segment. Appearing to rise from the tip of this segment are three short, conspicuous thick spines, which are also sensory in function.

The *vertex* (pl. LVI, fig. 1), as has already been mentioned, makes up the largest area of the dorsal part of the head, transversely occupying all that part of the head between the compound eyes and longitudinally all the part between the occiput and tylus. In length and width it is about equal. In the anterior portion of the vertex is the subquadrate invagination into which the front is inserted. The suture between the front and vertex is very distinct and firm, but the parts of the vertex bounding the front laterally do not appear to be fastened to the latter, but only to fit down over the line of union of the front and the reflexed corners of the clypeus. The posterior margin of the vertex is broadly emarginate, into which the rounded margin of the prothorax fits snugly, while the lateral margins round to a blunt apex.

The *occiput* (pl. LVI, fig. 1) is not visible until after the head has been removed from the body, since it occupies the central portion of the caudal surface of the head, or that part which lies against the cephalic surface of the pronotum. It is a single sclerite, forming the upper boundary of the occipital foramen and the posterior boundary of the vertex. Laterad the lower ends of the occiput fuse with the postgenæ, so that the suture appears to stop at a point in a line with the inner margin of the eye.

The *postgenæ* (pl. LVI, fig. 1) occupy the remainder of the caudal surface of the head. They are triangular in shape, with the sharply tapering apex extending between the vertex and occiput. The upper boundary of each postgena is formed partly by the lower margin of the eye and partly by that of the vertex. Its outer margin is the outer limit of the head and its lower end is fused with the occiput.

The *frons*, or front (plate LVI, fig. 1), commonly spoken of as the tylus, as will be noted from the foregoing, is located on the dorsal surface of the head. It is subquadrangular in shape, about one-third the width of the vertex and about one-half its length.

The *clypeus* (pl. LVI, fig. 2) is located on the ventral surface of the head. Its position has been determined by the fact that the forearms of the tentorium extend to its laterocephalic angles.

The clypeus is enormously enlarged and protruding, subquadrangular in shape, widest in the middle and narrower toward each end. In size it extends practically two-thirds the length of the head and over one-half its width. On each lateral margin is a row of parallel grooves separated from each other by a plain, wide, chitinous band. These are lighter than the surrounding parts and therefore stand out clearly. The peculiar reflexed condition of the

anterior corners and their connection to the front have already been described under the discussion of the tentorium.

The *labrum* (pl. LVI, fig. 2) is a flask-shaped sclerite with its broad end attached to the clypeus and its apex truncated. In length it is half the size of the clypeus and in width equal to the width of the clypeus in the neighborhood of the clypeal suture, but narrows down to half the width at its distal end. The suture between the clypeus and the labrum is indistinct along the median line, but is plainly indicated at the sides. The labrum is heavily chitinized and appears to be quite rigid.

Attached to the caudal end of the labrum and lying on top of the base of the stylets is a small triangular sclerite. This is the *epipharynx* (pl. LVI, fig. 2). It is very thin and lightly chitinized, for which reason it is not readily seen.

The *genæ* (pl. LVI, fig. 2) occupy most of the lateral parts on the ventral aspect of the head. They are irregular in shape with their lateral margins following the contour of the compound eyes and their median margin touching the clypeus and the maxillary sclerite. Caudad they form the outer margin or boundary of the head, which also is the suture between the genæ and postgenæ.

The *occipital foramen* (pl. LVI, fig. 1) is the opening visible from the caudal aspect of the head. It is bounded dorsad by the occiput and laterally by the postgenæ and mandibular sclerites.

The *rostrum* (pl. LVI, figs. 1 and 2), or beak, is composed of the labium and two pair of stylets, which are modified maxillæ and mandibles. The *labium* is composed of three segments. The basal segment is the shortest of the three and cylindrical in shape. The second segment is the longest, being about three times the length of the first and twice the length of the distal segment. The last segment is rounded at the tip, its margins seemingly more completely folding around the stylets. The beak is straight and extends backward between the middle coxæ for half their length. The labium is connected by a membrane to both the head and sternum of the prothorax, its point of attachment being just above the tip of the labium. The attachment to the head seems to be the weaker of the two, for when the prothorax is detached from the head the labium usually comes off with it. There is a groove along the ventral surface of the labium, in which repose the maxillæ and mandibles.

The *mandibles* and *maxillæ,* as in other Homoptera, are setiform or bristlelike. The mandible is connected to the head by a slender,

chitinous rod at a point where the caudal corners of postgenæ are joined to the mandibular sclerite. The maxilla is fastened to the anterior corner of the maxillary sclerite, which places it cephalad of the mandible. Funkhouser (1917) states that in the Membracidæ they are attached to the vertex, which differs from the condition found in most other insects, where they are attached to the postgenæ. In *Lepyronia quadrangularis* neither of these conditions occurs, but the close approximation of the mandibular sclerite to the postgena may be significant.

In order to study the structure of the tips of the mandible and maxilla it was necessary to study them under high magnification. Both stylets are cylindrical in shape, tapering toward a blunt point and with their hidden bases broadening into flat plates. The outer margin of the distal third of the mandible is finely notched, while the outer apical part only of the maxilla is modified into five distinct, rounded teeth (pl. LVI, fig. 4). The maxillæ appear to be equal to the labium in length, but the mandibles are slightly longer, so that their tips protrude a short distance beyond the tip of the labium.

The four stylets are closely associated, converging at the place where the labium is attached to the head. Here the mandibles become joined together by their inner margins, forming a shallow sheath in which the maxillæ lie. The maxillæ are also united, probably forming a tube, as in the *Cicada* (Snodgrass, 1921), through which the sap is sucked up into the pharynx. The maxillæ of *Lepyronia*, however, do not appear to be so firmly joined as in the *Cicada*, for their tips often spread apart, until from a superficial view, they appear to be on the outside of the mandibles.

The *maxillary sclerites* (pl. LVI, fig. 2) are the large semicircular sclerites on the ventral aspect of the head, bounded laterad by the genæ, caudad by the mandibular sclerites, and mesad by the clypeus and labrum. The cephalic tip of each maxillary sclerite is connected to the maxilla by a slender, chitinized branch of the latter. These sclerites are homologous to the loræ of the Cicadellidæ. Snodgrass (1921) considers them as definite sclerites, but attaches no name to them.

The *mandibular sclerite* (pl. LVI, figs. 1, 2) extends from the caudal angle of the genæ and postgenæ to the base of the labium. Each sclerite is elongate, narrow at the base, but widening in the middle to a flangelike projection and tapering to a tonguelike apex which partially folds around the base of the stylets. The interior

surface of this flangelike part forms a pocket or fold, called by Martlatt (1895) a pseudo-sheath, which receives and partially protects the mandible. It is connected to the mandible, as in the maxilla, by a chitinous arm of the stylet. It may be possible that the mandibular sclerite is comparable to the sclerite found in lower orders of insects, which is termed the *trochantin of the mandible* by Comstock and Kochi (1902) or the *basimandibulæ* by Crampton (1921).

THE THORAX.

The prothorax, as is shown in (pl. LVI, fig. 6) is weakly attached to the mesothorax, but is closely associated with the head, since it invariably comes off with the head when the latter is removed from the body. The mesothorax and metathorax, however, are firmly joined and the sclerites somewhat overlap on the dorsal surface, making identification of the sclerites rather difficult.

There is no evidence of *cervical intersegmentalia* in *Lepyronia,* or of any structures which might suggest them. The cephalic surface of the prothorax appears to fit directly against the caudal surface of the head without any intervening structures which might be termed these sclerites.

THE PROTHORAX.

The *notum* (pl. LVII, fig. 1) of the prothorax is a large, flat sclerite occupying the entire dorsal surface of this segment. It is twice as long as wide and has its short, lateral margins nearly parallel. The anterior margin is broadly rounded. The posterior margin is deeply emarginate on the produced middle third. The edges of the notum are greatly deflexed so that they unite with the pleuron on the ventral surface.

From a cephalic aspect of the pronotum (pl. LVII, fig. 5) can be seen a narrow sclerite, which probably corresponds to the sclerite in the *Cicada* termed by Taylor (1918) the *pretergite.* Mesad this sclerite is very narrow, but laterally it widens out to four or five times its median width. It lies at right angles to the notum and is connected to the pleuron by a tapering projection. The pretergite is not as heavily chitinized as the notum and pleuron.

The *pleuron* (pl. LVII, fig. 3), of the prothorax is closely joined to the deflexed part of the notum without a distinct line of connection. It is divided longitudinally by a very indistinct *pleural suture* into two sclerites, the *epimeron* and *episternum.* The *episternum,* the anterior of the two, is roughly rectangular in shape and about twice as long as wide. The *epimeron* is slightly larger than the

episternum, more irregular in shape and extends dorsad into a tapering point. The episternum is connected to the sternum by a narrow *precoxale bridge* (pl. LVII, fig. 4), called the *precoxale* by Taylor (1918). It is fused to the ventroentad surface of the episternum and it is not distinctly separated from the sternum. The epimeron is connected in much the same manner by a *postcoxale bridge* (pl. LVII, fig. 4) which, however, runs to the laterodorsal angle of the epimeron instead of the ventral.

The *sternum* (pl. LVII, figs. 4 and 5) of the prothorax is small and about equal in length and width. It consists of a single sclerite, which is folded and curved in such a manner that it is difficult to describe its exact shape.

The anterior margin of the sternum is bent back against the caudal surface of the sclerite (pl. LVII, fig. 4), so that in an uncleared specimen it appears as a chitinous ridge or distinct sclerite. In the drawing of the cephalic aspect this has been straightened out into a natural position. The lateral margins of the sternum (pl. LVII, fig. 5) curve cephalad, thus forming a semicylindrical cavity into which the membrane connecting the labium with the sternum is fastened. During the process of sucking the sap the labium is probably drawn up into this trough in order to not interfere with the action of the stylets. The anterolateral angles of the sternum bear the *furca* (Taylor, 1918), which are the processes for the attachment of muscles.

The *trochantin* (pl. LVII, fig. 5) is a small but very distinct knob-like sclerite just below the ventral end of the episternum.

THE MESOTHORAX.

The *mesothorax* (pl. LVII, figs. 7 and 8) is closely connected with the metathorax, the latter being partially covered both on its dorsal and ventral surfaces by overlapping parts of the mesothorax. The mesothorax, likewise, is covered by the pronotum with the exception of the scutellum, the anterior margin of which follows the deeply incised posterior margin of the pronotum. The membranous sternellum of the mesothorax is fused with the presternum of the metathorax so that it is difficult to differentiate the two.

The *mesonotum* (pl. LVII, fig. 7) is divided into four distinct areas or sclerites. The first of these is the prescutum, which occupies the anteromesal portion and is bounded laterad by two longitudinal sutures which curve mesad for a short distance, thus indicating the caudal boundary of the sclerite. The prescutum is heavily chitinized in spite of the fact that it is entirely covered

by the pronotum. On its anterior margin it bears the *anterior phragma* (pl. LVII, fig. 7), a semimembranous, bilobed, narrow structure which is connected to the pronotum by a membrane.

The *scutum* (pl. LVII, fig. 7) of the mesothorax is an irregular sclerite, occupying the entire lateral regions of the notum. It appears to consist of two sclerites, since the anterior point of the scutellum almost reaches the caudal boundary of the prescutum. At its laterocaudal angles the scutum is deeply incised to allow for the wing processes.

The *scutellum* (pl. LVII, fig. 7) is composed of a large shield-shaped piece, which is visible externally and two narrow lateral portions which connect with the anal margins of the wing and are not visible externally. The large median part is separated from each lateral part by a narrow groove into which the deflexed claval portion of the wing fits.

There are several small sclerites to be found connecting the base of the wing with that of the notum. On the anterolateral corner of the scutum is a small piece, called by Taylor (1918) the *suralare*. It is marked by a cleft which extends forward. As in the *Cicada*, another cleft extending backward marks off a similar piece. Just in front of the incision made by these clefts is a small triangular, free plate, the *notopterale*. Caudad of this plate, imbedded in the membrane, is a larger, subrectangular plate called the *adanal pterale*. There is no indication of the presence of the *tegula*, which agrees with the conclusion of Taylor that the tegula is not present in the families of Homoptera outside of the Fulgoridæ and Cicadidæ.

Cephalad of the wing the notum is connected to the pleuron by a narrow *prealare bridge* (pl. LVII, fig. 7). The postscutellum is connected to the epimeron by a similar *postalare bridge* (pl. LVII, fig. 6).

The *postscutellum* is a narrow sclerite, entirely hidden by the scutellum and is membranous in structure.

The *pleuron* (pl. LVII, fig. 6) is somewhat more complicated than that of the prothorax. The pleuron, in fact, forms a major part of the ventral body wall, so that the shape of the episternum and epimeron can best be seen from a ventral view (pl. LVII, fig. 10.) The *pleural suture* (pl. LVII, fig. 6), is quite distinct, consisting of an almost straight line extending from the base of the prealare bridge to the base of the coxæ.

The *episternum* (pl. LVII, fig. 10) is a single sclerite, which is not divided into an anepisternum and katepisternum unless a diagonal elevated ridge is an indication of this division. The episternum

is irregular in shape, about as wide as long, and approximately equal to the length of the sternum. It is separated from the sternum by a distinct transverse suture. There is no precoxale bridge.

The *epimeron* (pl. LVII, fig. 10) is an elongate sclerite extending the entire length of the mesothorax. It is widest just behind the middle when viewed ventrally, and bears the *postalare bridge*, connecting it with the postscutellum just cephalad of its broadest point. The epimeron is partly divided longitudinally by a suture which runs parallel to the pleural suture, but which extends for only half its length. Like the episternum, it is fused to the sternum, being separated by the pleural suture.

The *sternum* (pl. LVII, fig. 10) of the mesothorax is composed of three sclerites—the presternum, the sternum proper, and the sternellum. The anterior one is the *presternum* (pl. LVII, fig. 10), which is a narrow collarlike sclerite, bounded laterad by the episterna and caudad by the sternum itself. It is slightly less chitinized than the sternum, especially towards its lateral margins. Along its anteromedian margin is a broad indentation into which the troughlike sternum of the prothorax is inserted.

The *sternum* (pl. LVII, fig. 10) is the major sclerite of the ventral part of the mesothorax. It is a bilobed sclerite, each lobe being somewhat inflated. They are separated from each other by a heavy, dark median line which resembles a suture. Just before this line reaches the caudal margin of the sternum it extends laterad as a short cleft which marks off a little flap on each lobe. The sternum is heavily chitinized and very dark colored. It is closely associated with the pleural sclerites, as was mentioned above, but is separated from both by very distinct and heavy sutures.

The *sternellum* (pl. LVII, fig. 10) is a partly membranous, partly chitinous sclerite, lying directly caudad of the sternum. It is a rather ill-defined region, somewhat semicircular, with its caudal, convex margin joined to the concave cephalic margin of the presternum of the metathorax. The chitin is deposited along the middle line of this sclerite as a broad, longitudinal band which sends out two lateral arms at its cephalic end which are entirely hidden by the overlapping sternum, and two lateral arms at its caudal end. The part of the sternellum which is chitinized is not very heavy, due to the fact that the large coxæ entirely cover it.

The *trochantin* (pl. LVII, fig. 10) is a very small but distinct sclerite, located between the laterocaudal angle of the sternum and the laterocephalic angle of the coxa.

THE METATHORAX.

The connection of the metathorax to the mesothorax has already been noted. It is weakly joined to the abdomen, not only because it is connected to the abdomen by a membrane, but also because the first segment of the latter is partly membranous itself. It is similar to the mesothorax in general make-up, especially in the number of sclerites.

The *notum* (pl LVII, fig. 9), as in the mesothorax, is composed of four sclerites—the prescutum, scutum, scutellum, and postscutellum. The *prescutum* is peculiar in that it is entirely internal, extending directly into the body cavity and lying at right angles to the scutum. It is a very large, bilobed sclerite, heavily chitinized, and is used for attachment of large bundles of muscles.

The *scutum* is the large, heavily chitinized sclerite found on the dorsal surface of this segment. It is rectangular in shape and its width is one and one-half times its length. Along its median line is a heavy, black line which is the external indication of an infolding of chitin, which also serves for muscle attachment.

The *scutellum* of the metathorax is much reduced, consisting of a small, median portion, which is produced laterad into a narrow band. The latter is directly connected with the anal margin of the wing.

The *postscutellum* is a flat chitinous sclerite, which is extremely narrow mesad, but which expands laterad into two tapering side processes. The cephalic margin of the postscutellum is attached to the anterior margin of the scutellum, which is the suture separating the scutum from the scutellum.' The diagonal, lateral angle of the postscutellum is directly attached to the margin of the epimeron and no postalare is present, as in the *Cicada*.

The *pleuron* (pl. LVII, fig. 8) is very well developed, being by far the largest part of the metathorax. It not only occupies all the pleural regions, but extends into the dorsal and ventral regions and forms a major part of the metathorax.

A distinct *pleural* suture extends the entire length of the pleuron. The episternum is an undivided sclerite, although on its caudal end is the beginning of a suture which runs parallel to the pleural suture. The episternum is the largest of the pleural sclerites, occupying the ventral half of the pleuron, the lateral third of the venter, and the laterocephalic angle of the dorsum, where it curves around the wing process.

The *epimeron* is likewise a large sclerite, but it is found chiefly on the lateral and dorsal parts of the segment. It occupies the dorsal half of the pleuron and lateral part of the dorsum, where mesad it touches the lateral margins of the scutum and postscutellum (pl. LVII, fig. 9). The lateral extensions of the metascutellum, which are joined to the axillary cord of the wing, lie on top of the epimeron. From a lateral view (pl. LVII, fig. 8) the indentation made by the wing process can easily be seen. Ventrally the epimeron shows as a plate forming the caudal boundary of the episternum. A suture divides the sclerite into an upper and lower portion. A flaplike process is present in the lower epimeron of Lepyronia, which is probably similar to that found by Taylor (1918) in an *Aphrophora*.

The *sternum* (pl. LVII, fig. 11) is small when compared to the sternum of the mesothorax. The *presternum* of this segment is partly membranous, with a weak deposition of chitin in its median and caudal portions. It is roughly crescentic in shape.

The *sternum* is entirely membranous and is divided into two distinct halves by a very narrow, chitinous band, which appears to be a caudal extension of the chitinous part of the presternum.

The *sternellum* appears to be a narrow, chitinous rod extending between the epimera, with which it appears to be fused. It is located beneath the posterior coxæ, and for this reason is more easily seen from a dorsal view than from a ventral view (pl. LVI, fig. 7).

The *trochantin* is a knoblike structure terminating the caudal end of the pleuron. It is termed by Taylor (1918) the meron, or at least he assigns this term to a similar structure in an *Aphrophora*, but does not account for a trochantin.

THE WINGS.

The *forewing* (pl. LVIII, fig. 4) of *Lepyronia* is thick, opaque and rather tough. Its entire surface is broken up into fine reticulations and is covered by a grayish pubescence, similar to that of the head. These conditions, together with the even coloring of the wing, entirely obscure the venation in uncleared specimens. It was only in half-bleached specimens that the veins could be traced at all. The venation of both wings here studied was found to be almost identical with the venation of the same species as described by Metcalf (1917).

Costa is a single, unbranched vein which forms the costal border.

Subcosta is so closely related to radius, at least distally, that it only appears as a definite vein along the center of its course, where it is widely separated from radius and thus forms an elongate, oval cell. *Radius* has three branches, which are R_1 and R_{2+3} and R_{4+5}. *Media* is unbranched and is closely connected with cubitus, at least at its base. *Cubitus* is two-branched. There are three *anal* veins present, the first one of which is united with cubitus 2 on the margin of the wing.

In the *hindwing* the veins show up very plainly, being brown in color and quite thick, while the cells of the wing are membranous. *Radius* is two-branched, the branches being R_{2+3} and R_{4+5}. *Media* is unbranched and *cubitus* is two-branched. Three *anal veins* are likewise present in this wing, the first one being closely connected with cubitus basally, while the third one is branched.

Part of the anterior margin of the posterior wing is produced into a triangular projection whose outer margin bears from four to six stout spines or hooks. Also on the ental surface of the tegmina just in front of subcosta is a little elevated keel. According to Hansen (1890) these hooks and keel are complementary structures and contribute to the steadiness of the wings.

THE LEGS.

The three pairs of legs have a general similarity with respect to position on the body, development, relative size, and number of segments. When in action the front legs usually point forward and the two last pairs point backward (pl. LV, fig. 1), but when at rest they are drawn up under the sloping tegmina (pl. LV, fig. 4) so that they are invisible from above. The hind pair is the longest and the other two are about equal in length. All are well developed as a result of their jumping habit. The number of segments is the same in each, consisting of coxa, trochanter, femur, tibia and a three-segmented tarsus. They are blackish brown in color, especially the proximal segments, but gradually grow lighter toward the distal ones. All three pairs are covered by a fine pubescence.

The *coxa* (pl. LVIII, fig. 3) of the front leg is stout and thick in comparison with the other segments of the leg, but it is not as large as the coxæ of the other two pairs. It is smooth and about equal in length and width. It is almost cylindrical in shape, although its proximal end broadens out transversely and thus gives the effect of a flattened plate. The two anterior coxæ are separated from each other by the width of the beak, which fits down between them.

The *trochanter* is a small elbow-shaped piece which is attached to the ventromesal angle of the coxa. It is slightly constricted at its cephalic end and is about one-fourth the size of the coxa.

The *femur* is a cylindrical-shaped segment which is somewhat swollen at the proximal end, but gradually becomes narrow distad. It is the stoutest of the leg segments outside of the coxa. The trochanter is attached to its mediocephalic angle by a diagonal line of connection. Its distal end bears a small groove into which the tibia is inserted, while the lateral margins of the groove expand into a platelike structure on either side of the tibia for the purpose of strengthening the joint.

The *tibia* resembles the femur in general shape. It is cylindrical, smooth, and approximately the same length as the femur, but its width is only half that of the femur. The proximal end, which fits into the grove of the femur, is elbowed. There are no spines on the front tibia.

The *tarsus* is three-segmented. The first two segments are about equal in length, triangular in shape and larger ventrally than dorsally.

The tarsus is terminated by two equal, heavily chitinized *claws* (pl. LVIII, figs. 6 and 9). The claws are broad at the base and gradually taper to an obtuse blunt point. The pulvillus or empodium, according to Hansen (1890), is very conspicuous and greatly extended. On its dorsal surface it bears a large, bilobed, chitinous plate, and just below this a bristle (pl. LVIII, fig. 6). On the ventral side (pl. LVIII, fig. 9) are two narrow, longitudinal bands which run parallel to the margins of the claws. These bands and part of the claws appear to be attached to the third segment of the tarsus by a lightly chitinized band or stalk.

The *middle legs* (pl. LVIII, fig. 2) are attached directly to the sternum by the broad, transverse margins of the coxæ. The trochantin of the mesothorax is much smaller than that of the prothorax and is situated on the extreme lateroeephalic angle of the coxa just above the meracanthus. The median leg, in most respects, is similar to the fore leg, being almost identical in size and shape of segments with the exception of the coxæ. The latter are somewhat larger than the anterior coxæ and their median margins are almost contiguous. They have on their lateral margins a large, flattened process or *meracanthus* which is not found on the other four legs.

The *posterior coxæ* (pl. LVIII, fig. 8) are more broadly attached to the body than even the intermediate coxæ are, since they extend

across the entire width of the sternum. The sternellum and the first segment of the abdomen is completely hidden by them, and part of the second and third segments of the latter are also covered. They are contiguous along their inner margins, which fact, together with their broad, basal attachment, gives them the appearance of great rigidity. In shape they are roughly rectangular with their latero-cephalic angle somewhat extended.

The *trochanter* of the hind leg is similar to those of the first two pairs of legs, in that it is an elbow-shaped segment and of the same size as the others.

The *femur* is a smooth, cylindrical-shaped segment, diagonally attached to the trochanter. On its proximal lateroventral margin is an oblique protuberance (pl. LVIII, fig. 7), which, according to Hansen (1890), occurs in all Cercopidæ, but in no other Homoptera. The knee joint is strengthened, as in the two anterior pairs of legs, by the groove and side plates of the femur, which are very prominent and show plainly in figures 7 and 8 (pl. LVIII).

The *tibia* of the hind leg is greatly lengthened. Basally it is quite narrow, but broadens to twice its width distad. Along its outer margin it bears two large, thick spurs, which are of taxonomic importance in distinguishing the family. The second of these is approximately twice the size of the first in both length and thickness. The distal end of the tibia bears two rows of thick, sharply pointed spines. The average number of spines, after counting twenty specimens, was seven on the top row and eight on the lower. These spines are shiny black at the tip and from between each two of them arises a long, silken hair which is twice the length of the spines.

The *tarsus* is composed of three segments, the first two of which are similar in shape to the tibia, being narrow at the base and spatulate at the tip. They also bear a row of spines on their distal ends, which are like those of the tibia in shape and color but which are only half as large. The average number of spines on the first segment is seven, and on the second, nine to eleven. The distal segment of the tarsus is swollen but not spatulate.

THE ABDOMEN.

The number of segments in both the male and female abdomens is eleven plus a telson. From a dorsal and lateral view the abdomen is not visible, since the sloping tegmina completely hide it. It can, of course, be easily seen from a ventral view, but owing to the enlarged hind legs, especially the coxæ, and the fact that its segments

are more or less telescoped, few details of structure can be made out without first removing the legs. Its color is like that of the rest of the body, and is uniform throughout with the exception of the sutures, which are somewhat lighter in color, indicating their membranous nature. The abdomen is very wide at its base, but tapers to a pointed apex, due to the fact that the segments decrease in size from front to rear. Each segment overlaps the following one, which produces a telescopic effect. The segments are divided into three general regions—tergum, pleuron, and sternum. The tergum occupies all the dorsal region, while the pleuron and sternum are to be found on the ventral surface.

The ventral, dorsal and lateral views of the male abdomen are shown on plate LIX, figs. 1, 2 and 3. The first segment was difficult to find, owing to its irregularity of shape and its half-membranous structure. The *tergum* is partly membranous and partly chitinized, although the chitin is very weak even where it is present Along its cephalic margin is a transverse, chitinous band, which mesad is very narrow but which is broadly expanded laterad. This anterior band is separated from a similar posterior, chitinous band by a strip of membrane. The first tergum appears to be attached to the postscutellum by a membrane.

The *pleuron* (pl. LIX, fig. 2) of the first segment is greatly reduced and occupies a peculiar position on the abdomen. It is a small, triangular, heavily chitinized plate lying on the laterocaudal angles of the tergum. This is the only pleuron visible from the dorsal view of the abdomen, but is easily recognized as such by the distinct spiracle located near its upper margin.

The *sternum* is also greatly modified. Its anterior margin is produced into a flaplike structure which bends forward on the remainder of the segment, due to pressure from the thorax (dotted line, pl. LIX, fig. 1). The lateral parts of the first sternum are membranous and deeply depressed where the chitinous angles of the thorax fit down against it.

The *tergum* of the second segment is entirely chitinous, not extending across the entire dorsal surface of the abdomen, but with its lateral, rounded margins extending cephalad and bounded by the cephalad-projecting corner of the third tergum.

The *pleuron* (pl. LIX, fig. 1) of the second segment is of the same shape as the pleuron of the first, but is somewhat smaller. The relation of the two can be seen from a lateral view (pl. LIX, fig. 3). The two bases of the triangles adjoin each other, while the apices

extend dorsad and ventrad, respectively. The spiracle of this pleuron is difficult to locate, since it lies near the mesal margin of the pleuron and is visible only from a ventral view of the abdomen.

The *sternum* of the second segment is an elongate, narrow, chitinous band which tapers laterad to a fine point. Superficially this is taken as the first sternite, since the latter, because of its membranous condition, usually is pulled off with the thorax when it is removed.

The third to eighth segments are practically all alike, being ring-like, in form and differing only in size. The terga are heavily chitinized and occupy the entire dorsal surface. The pleura are roughly rectangular, somewhat inflated, and with both lateral and median angles slightly rounding. The pleura are wider than either the sterna or terga. The sterna are elongate, rectangular plates forming the real ventral wall of the abdomen.

The *pygofer* or *gonomere* is the modified ninth tergite, which is a rounded, bulblike structure, bearing on its dorsal surface the anal tube. The ninth sternite forms the plate beneath the genital apparatus, and is called by Crampton (1922) the *hypandrium* (pl. LIX, fig. 1). These make the ninth segment a very prominent segment of the abdomen.

The anal tube (pl. LIX, fig. 2), as was stated above, is situated on the dorsal surface of the abdomen, apparently fitting into a circular depression and connected to the pygofer by a membrane. It is composed of two segments, which represent the tenth and eleventh abdominal rings or uromeres. The tenth uromere is by far the larger and is termed by Crampton the *proctiger*. The eleventh segment bears the telson, which is triangular in shape and is divided in the middle into two distinct halves by the anus.

The female abdomen (pl. LIX, figs. 4, 5, and 6) is similar to that of the male in most details. The first tergum is both membranous and chitinous, but differs from the male in that there is only a single, irregular band of chitin along its cephalic margin instead of two. The first sternum and pleuron are much the same as in the male.

The second to seventh segments of the female show little difference from those of the male. The eighth sternum, however, has been slightly modified to admit the ovipositor. It is divided into two distinct halves by the bases of the ovipositor valves, which extend cephalad until they reach the caudal margin of the seventh sternum. Each plate of this sternum is an inverted right-angled triangle,

with its caudal margin somewhat curving. The eighth pleura and tergum appear quite normal.

The ninth segment, or *pygofer,* is greatly enlarged and inflated, even more so than in the male. The anal tube is borne on its dorsal surface, but occupies a more caudal position than in the male. For this reason the pygofer is more bulblike, extending around on the ventral surface, and thus making up a large share of the posterior end of the female abdomen. Its median margins do not meet on the ventral surface, since the valves of the ovipositor extend between them. There appears to be no ninth pleuron externally, as its position is occupied by the tergum, but a remnant of the ninth sternum (pl. LIX, fig. 6) is to be seen, forming the two slender basal parts of the dorsal valves of the ovipositor.

The *anal tube,* as in the male, consists of the tenth and eleventh segments plus the triangular telson, and is attached to the posterior region of the pygofer by a membrane which fits into a circular opening. The eleventh segment is greatly reduced, however, being about one-eighth as long as the same segment of the male.

THE MALE GENITALIA.

From an external view of the abdomen part of the so-called "internal genitalia," as well as the "external genitalia," are visible. The organs usually included as "internal genitalia" are the paired styles, the œdagus and the connective. The parts which are exposed are the apical two-thirds of the styles. These are plainly visible on the dorsal surface of the abdomen and have no protective covering of any sort.

The basal parts of the styles, the connective, and the œdagus are situated in a genital or terminal chamber formed by the pygofer and anal tube. Since this chamber is really not closed, but is open beneath the anal tube, these parts are not really internal, but are only designated as such for convenience.

There is no indication of the presence of the diaphragm, which Gifford (1922) found to be present in the genital chamber of the Delphacidæ. In fact, the entire genital chamber of these insects varies considerably from that of *Lepyronia.*

The *genital plates* (pl. LIX, fig. 1) are two valvelike processes on the ventral surface of the abdomen. They have been given various names, such as hypovalvæ, ventral plates, and genital plates. They are large, prominent flat plates, occupying most of the apical end of the abdomen, and are broad at the base but taper to a pointed

apex. These plates, as is shown from nymphal development, arise from a genital area on the ninth segment. They are indistinctly fused with the caudoventral margin of the pygofer or with the area termed by Crampton (1922) the *hypandrium*. The lateral margins of the hypandrium are indistinguishably united with the lateral margins of the pygofer. The plates are separated along their mesal lines by a long cleft which extends nearly to the eighth sternite.

The *styles* (pl. LXI, figs. 7 and 8) have been given various names, such as gonistyli, claspers, or genital styli. They are very irregular in shape. At their cephalic end they taper to a very slender point, while their caudal end is truncate. The widest part of the style is at the point of attachment to the connective. Just cephalad and caudad of this point it is constricted, but it broadens out again caudad of the latter constriction into a second enlarged part. At this particular point on the dorsal surface of each clasper arises a prominent hook, the tip of which extends in a cephalomesal direction. From a lateral view of the genitalia (pl. LXI, fig. 5) the nature of the relation of this hook to the style can best be seen. Just distad of each hook is a slight notch in the clasper. The apex of the organ bends mesad in a distinct curve. The styli are connected to the ventral wall of the pygofer at about the laterocephalic angles of the hypandrium, and they extend directly caudad. They are fastened to the connective only at its extreme lateral tip by a very narrow band of membrane, although the connection would seem to be much greater, since from a ventral view of the organs the connective covers a large part of the claspers on each side. The union of the two can be seen from a ventral and lateral view of the genitalia. The styli are fairly well chitinized, but not enough to keep them from being flexible. Their function is that of clasping or interlocking during copulation.

The *connective* (pl. LXI, figs. 7 and 8) is a flat chitinous plate, roughly triangular in shape, which extends between the two claspers and is attached to the latter at about the base of their anterior third. The lateral margins are produced into a slender recurved hook which extends cephalad and whose inner margin is attached to the styli. The broad basal part of the connective is chitinized, but the apical region is entirely membranous. Bordering this membrane on the sides are two slender, chitinous rods which extend caudad, where their tapering points are attached to the ventral surface of the base of the œdagus. It has been suggested by Doctor Lawson that the connective may possibly represent the tenth sternite, since its origin has not otherwise been accounted for.

The *œdagus* (pl. LXI, figs. 7 and 8) is a term applied to the structure containing the penis. It has been called by other writers the penis sheath, or merely the penis. It too arises from a genital area on the ninth segment. In texture the œdagus is quite heavily chitinized and is very smooth and shiny. Basally the œdagus is club-shaped, flattened dorsoventrally, and gradually narrowing to a long, slender, chitinous tube which extends cephalad to a point beyond the anterior tips of the styles. Its apex is broadened into a flat plate, whose laterocaudal angles bear two longer, slender, tapering hooks, the penis hooks, which extend directly caudad.

From the center of the broad plate there appears to arise a slender, membranous tube, which also projects caudad, parallel with the penis hooks. At the apex of the tube is a circular opening or *gonopore*. There is also another circular opening at the base of the œdagus, which is probably the opening of the ejaculatory duct. The flat apical part of the œdagus lies directly beneath the proctiger or tenth uromere. The latter has on its lateral margins a small hooklike structure (pl. LIX, fig. 2) which seems to fit down around the œdagus and which may correspond to the *surgonopods* of Crampton (1922). The œdagus is protective in function, since it serves to protect the delicate penis.

THE FEMALE GENITALIA.

On the female the genitalia consist of three pairs of appendages, which collectively are often spoken of as the ovipositor. More properly speaking, however, the ovipositor is made up of only two pairs of valves, the ventral and dorsal, and the lateral pair form a sheath around them. The eighth sternum of the abdomen, as was noted above, is divided into two distinct plates by the processes of the ovipositor, while the ninth sternite is represented by two small rectangular sclerites to which the lateral valves of the ovipositor are attached.

The *lateral valves* (pl. LX, fig. 3) have been given other names in the literature, such as outer valves, posterior processes, or ovipositor sheaths. They are the outermost of the three pairs and fold around the inner pairs as is shown in figure 1. They arise from a genital area on the ninth segment and are attached in the adult to the vestigial parts of the ninth sternite. The attachment is broad and transverse to the caudal end of the sternite. Each lateral valve is a broad, spoon-shaped appendage which is deeply concave on its inner surface, so that half of it shows from a ventral view of the genitalia (pl. LX, fig. 1) and half from a dorsal view (fig. 6).

Its ventral basal part appears to be entirely membranous. The pygofers fit very snugly around the lateral valves, but are not attached to them. These valves are tough, fairly well chitinized and with their outer surfaces pubescent. Their ventral surfaces are plainly visible from an external view.

The *ventral valves* (pl. LX, fig. 2) are the middle pair of valves. Other names which have been applied to them are middle valves, anterior processes or ventral processes. They arise from the eighth sternite, to which they are still attached in the adult. Each valve is fastened to its half of the eighth sternite by a membrane which connects the mesal corner of the sternite and the cephalomedian angle of the valve. They are flat rather broad processes, which taper to a fine point and which bear a broad notch near the base of the dorsal margin. The ventral valves enfold the dorsal valves and the ventral and dorsal valves of each side are fastened together by a tongue-and-groove connection. The ventral valves are not as heavily chitinized as either the lateral or dorsal ones.

The *dorsal valves* (pl. LX, fig. 5), which have also been called inner valves or median valves, are the innermost of the three pairs of valves, and make up the ovipositor proper. They arise from a genital area on the ninth segment of the nymph and are still attached in the adult stage to the cephalic end of the ninth sternite. Each valve is a flat, bladelike structure, broader at the base, but tapering to a pointed apex. The basal half of their inner or dorsal margins are united and the free apical portions bear teeth. These teeth are small, sharply pointed, with broad, shallow indentations between them, and are about fifteen in number. The teeth are used as a saw with which to cut the plant tissue. The ventral margins of these valves bear heavily chitinized grooves into which the tongues of the ventral valves are inserted.

Extending along the approximate median line of the ventral valves is a slender, chitinous rodlike structure. Superficially this appears to be a chitinous thickening of the valve, but when it is traced cephalad it is not found to be attached basally to the sclerite to which the valve is fastened. The sclerite to which it is fastened is a small, triangular plate (pl. LX, fig. 4), which is attached to the lateral margins of the ninth sternite, the cephalic margin of the pygofer, and normally lies hidden beneath the eighth sternite. It probably represents the ninth pleurite.

DEVELOPMENT OF THE GENITALIA.

As early as the third instar the nymphal genitalia are not only distinctly visible, but furnish reliable characters by which to distinguish the sexes. They cannot be clearly made out, however, in the first two stages without careful study.

The *male genitalia* arise from a genital area on the ninth abdominal segment. In the first and second instars only one pair of valves is present. Superficially they appear as two opaque, elongate, elevated ridges which occupy the major part of the ninth sternite. Closer examination reveals that they are two chitinous pockets (pl. LXI, fig. 1), which are separated from each other by a median chitinous band and which produce the genital appendages of the next nymphal stage. The pockets are attached to the caudal border of the genital area with their apices directed caudad and are rounded at the tip. The genital area is comparatively short and extends cephalad under the caudal margin of the eighth sternum, due to the telescopic arrangement of the abdominal segments, so that at first glance the pockets appear to arise from the eighth sternite. This pair of pockets produces the genital plates of the adult.

In the second instar (fig. 2) the pockets have increased slightly in size, but are similar in other respects to those of the first.

In the third instar there is a noticeable increase in size of the genital area. The pockets of the genital plates have become broader but are not so deeply bilobed. In addition to the one pair of pockets there is now present another pair, which are located dorsad and slightly caudad of the first pair. These produce the genital styles or claspers of the adult insect.

In the fourth instar the genital area has become large and prominent. There is a great increase in the size of the dorsal pockets, which have now become twice as long as the ventral pair. Both are rounded at the tip.

In the fifth instar still greater changes have taken place. The ventral pockets have become greatly elongated and their apices have diverged slightly. The genital area has lengthened between the ventral plates and the dorsal plates so that the former do not extend over the latter at all. The dorsal pockets have also diverged considerably, and between them can be seen the apices of another pair of pockets. These median pockets are only half as long as the pockets of the genital styles, are rounded at the apex and produce the œdagus of the adult.

The *female genitalia* in the first and second instars (pl. LXII, figs. 1 and 2) are very difficult to distinguish from those of the male. There are two pairs of valves present, but since they are practically of the same color and texture and one pair is placed upon the other, they appear as a single pair and therefore resemble the male. The first pair are small, rounded at the tip and project from the eighth sternite as a caudal extension of the latter. Thus it is clearly evident that they arise from the eighth sternite, whereas in the male the posterior margin of the eighth sternite can be seen to lie on top of the first pair of pockets. This pair of pockets develops into the ventral valves of the adult ovipositor. The second pair of pockets, which produce the dorsal valves of the ovipositor, project from above the first pair and are twice as long as the first pair. Together they occupy about one-half the length of the ninth sternite.

In the third instar the ventral pockets have increased both in width and length. Here they are more easily seen to be attached to the eighth sternite. The dorsal pockets have become greatly enlarged. They are entirely separated from the ventral pockets, occupying about the center of the ninth sternite. The lateral pockets are present in the third instar for the first time. They lie laterad of the dorsal pockets, are somewhat narrower, although much longer, and curve slightly mesad. They develop into the lateral valves of the adult.

In the fourth instar the ventral plates are greatly enlarged, so that their apices reach the base of the dorsal valves. The dorsal valves are larger than in the preceding instars, but are still the smallest of the three pairs. The lateral pockets, which are the largest pair of pockets, have their apices projecting much farther caudad than the dorsal valves and their bases reaching cephalad almost to the eighth sternum.

In the fifth instar the pockets are very prominent. The ventral pockets are broad at the base, extending the entire width of the sternum and taper gradually to narrowly rounded apices. The dorsal valves are somewhat the shape of the ventral and are entirely covered by the latter. Their bases, however, do not reach to the eighth sternum. The lateral pockets are fingerlike structures with their bases partly covered by the ventral valves and are still slightly longer than either of the other two pairs. The genital area is very prominent and has been pushed cephalad until it occupies all the eighth sternum, and even extends into the seventh, where the indica-

tion of the division of the eighth sternum in the adult is shown by the division of the nymphal integument.

From the foregoing studies it appears that the male and female genitalia are not strictly homologous, since the three pairs of valves in the male arise from a genital area on the ninth segment, while in the female one pair comes from the eighth and two from the ninth. This agrees with Kornhauser's (1919) work on a membracid and Hackman's (1923) work on a cicadellid. Kershaw and Muir (1922) in their studies of a cercopid, *Philænus leucophthalmus*, make the statement that the gonopophyses of the male arise in exactly the same place as in the female. This conclusion appears to be drawn from a study of the fourth and fifth instars only, which are not sufficient to give a true interpretation of the origin of these organs.

BIBLIOGRAPHY.*

AMYOT, C. J. B., and SERVILLE, J. G. AUDINET. Histoire Naturelle des Insectes. Hémiptéres, p. LXIII, p. 567; 1843.

ASHLEY, K. The Froghopper or Cuckoo Spit on Roses. Review of App. Ent., vol. VII, ser. A, part 5, p. 209; 1919.

ASHMEAD, W. H. A Proposed Classification of Hemiptera. Ent. Am., 4:67; 1888.

BAKER, CARL F. Notes on *Philænus*. Canad. Ent., 29:111-112; 1897.

BAKER, CARL F. The Malayan Machærotinæ (Cercopidæ). The Philippine Journ. of Sci., (Sept.) XV, No. 1:67-78; 1919.

BALL, E. D. A Study of the Genus *Clastoptera*. Reprint from Ia. Acad. Science, 3:182-193; 1896.

BALL, E. D. A Review of the Cercopidæ of North America north of Mexico. Rept. Ia. Acad. Science, pp. 204-226; 1898.

BALL, E. D. The Food Habits of Some Aphrophora Larvæ. Ohio Nat., 1:122-124; 1901.

BALL, E. D. Adaptations to Arid Conditions in Cercopidæ and Membracidæ. Annals Ent. Soc. of America, 8:365-368; 1915.

BALL, E. D. Notes on Cercopidæ, with Descriptions of Some New Species. Ia. Acad. of Sci., 26:143-149; 1919.

BALL, E. D. Life Cycle in Hemiptera. Annals Ento. Soc. of Am., 13:143; 1920.

BARBER, GEORGE W., and ELLIS, WM. O. Oviposition of Meadow Froghopper and Grass-feeding Froghopper. Psyche, 29, No. 1; 1922.

BORING, ALICE M. A Study of Spermatogenesis of Twenty-two Species of Membracidæ, Jassidæ, Cercopidæ and Fulgoridæ, with special reference to the behavior of the Odd Chromosome. J. Exp. Zoöl. Balt. Md., 4:469-512; 1907.

BRANCH, HAZEL E. The Morphology and Biology of the Hembracidæ of Kansas, vol. VIII, No. 3:75-111; 1913.

BUGNION, E., and POPOFF, N. The Mouthparts of the Hemiptera. Arch. Zoöl. Exp., 47:643-674; 1911.

COMSTOCK, JOHN H. and ANNA B. Manual for Study of Insects, p. 153; 1895.

COMSTOCK, JOHN H., and KOCHI, CHIJIRO. The Skeleton of the Head of Insects. Amer. Nat., 36:13-45; 1902.

CRAWFORD, DAVID L. A Monograph of the Jumping Plant Lice or Psyllidæ of the New World. Smith. Ins. U. S. Nat. Mus. Bull., 85:1-182; 1914.

CRAMPTON, G. C. Notes on the Thoracic Sclerites of Winged Insects. Ent. News., vol. 25, No. 1:15-25; 1914.

CRAMPTON, G. C. Genitalia and Terminal Abdominal Structures of Male Neuroptera and Mecoptera, with Notes on the Psocidæ, Diptera and Trichoptera. Psyche, 25, No. 3:47-59; 1918.

CRAMPTON, G. C. Comparison of Genitalia of Male Hymenoptera, Mecoptera, Neuroptera, Diptera, Trichoptera, Lepidoptera, Homoptera and Strepsiptera with Those of Lower Insects. Psyche, vol. XXVII, Nos. 2 and 3, pp. 34-43.

CRAMPTON, G. C. The Genitalia of the Males of Certain Hemiptera and Homoptera. Bull. Brook. Ento. Soc. vol. XVII, No. 2:46-55; 1922.

FELT, EPHRAIM PORTER. Twenty-first Report of New York State Entomologist, p. 94; 1905.

FITCH, ASA. Transactions of New York State Agriculture Society, p. 389; 1856.

FABRE, J. H. The Production of Foam by *Aphrophora*. Souvenirs Entomologiques. (Septième Série.) Paris, 800, pp. 219-233; 1900.

* Only the papers that apply more or less closely to the subject matter have been used.

FUNKHOUSER, W. D. Biology of the Membracidæ of the Cayuga Lake Basin. Cornell Univ. Agric. Exp. Sta., pp. 181-445; 1917.

FIGGARD, W. M. The Systematic Value of the Male Genitalia of Delphacidæ. Ann. Ento. Soc. Amer., vol. XIV, No. 2, pp. 135-140; 1921.

GODING, F. W. Synopsis of Subfamilies and Genera of North American Cercopidæ. Bull. Ill. St. Lab. Nat. Hist., III, p. 483; 1895.

GARMAN, PHILIP. The Grass-feeding Froghopper or Spittle Bug. Conn. Agric. Exp. Sta. Bull. 230: 327-334; 1921.

GARMAN, PHILIP. Notes on the Life History of *Clastoptera obtusa* and *Lepyronia quadrangularis*. Ann. Ento. Soc of Amer., vol. XVI, No. 2, pp. 153-160.

GILLETTE, C. P., and BAKER, CARL F. Hemiptera of Colo., p. 71; 1895.

GUFFY, P. L. Report of the Entomologist in charge of Froghopper Investigation for the Months of October and November, 1914. Rev. of Appl. Ento., Ser. A., vol. III, part 4:207; 1915.

GRUNER, M. Beitrage zur Frage des Aftersecretes der Schaumcicaden. Zoöl. Anz., 23:431-436; 1900.

HACKMAN, LUCY M. Studies on *Cicadella hieroglyphica*. Kan. Univ. Sci. Bull., vol. XIV; 1923.

HARRIS, T. W. Treatise on Insects Injurious to Vegetation, p. 225; 1862.

HUNGERFORD, H. B. Biology and Ecology of Aquatic Hemiptera. Univ. of Kansas. Sci. Bull., vol. XI, No. 17:1-341; 1919.

HARPER, J. O. Details of Structure of *Aphrophora spumaria*. Sci. Goss., pp. 52-54; 1874.

HEYMONS, R. Beitrage zur morphologie und entwicklungsgeschichte der Rhynchoten. Nova Acta Acad. Leop. Carol., Bd. LXXIV, No. 3. Summary by author in the Zoöl. Centrlbl., 7:33-36; 1897.

HANDLIRSCH, A. Wie viele stigmen haben die Rhynchoten. Ein morphologischer beitrag. Verh. ges. Wien., pp. 49-510; 1899. Summary. Zoöl. Centrabl., VII, p. 251.

HANSEN, H. J. Gamle og nye kovedmomenter til Cicadariernes morphologi og systematik. Ent. Tidskr., 11:19-76; 1890. Translated by Kirkaldy in Entomologist, vol. 33:117, 172, 337; vol. 34:152; vol. 35:216; 1900.

KERSHAW, J. C. Froghoppers. Dept. Agric. Trinidad, Special Circular Nos. 4 and 5. Summary in Rev. of Appl. Ento., vol. I, ser. A, part 7, p. 233; 1913.

KERSHAW, J. C. The Alimentary Canal of a Cercopid. Psyche, 21:65-71.

KERSHAW, J. C., and MUIR, F. The Genitalia of the Auchenorhynchus Homoptera. Annals Ento. Soc. of Amer., vol. XV, No. 3, pp. 201-212; 1922.

KORNHAUSER, SIDNEY I. The Sexual Characteristics of the Membracid *Thelia bimaculata* (Fabr.). Journ. of Morph., vol. 32, No. 3, pp. 531-636; 1919.

KIRKALDY, G. W. Phylogeny of Homoptera. Canad. Ent., 42:83; 1910.

LAWSON, PAUL B. Cicadellidæ of Kansas. Kan. Univ. Sci. Bull., vol. XII, No. 1, p. 1-373; 1920.

LINTNER, J. A. Ninth Report of New York State Entomologist, p. 393; 1893.

MEEK, WALTER J. On the Mouthparts of the Hemiptera. Kan. Univ. Sci Bull., vol. II, No. 9:257-277; 1903.

MARLATT, C. L. The Hemipterous Mouth. Proc. of Ento. Soc. of Wash., vol. 3:241-250; 1896.

METCALF, Z. P. The Wing Venation of the Cercopidæ. Annals. Ento. Soc. Amer., 10:27-34; 1916.

MONROE, E. S. A Bubble-blowing Insect. Reprint from Appleton's Popular Science Monthly, May, 1900.

NEWELL, ANNA GRACE. The Comparative Morphology of the Genitalia of Insects. Annals of Ent. Soc. Amer., vol. XXI, No. 2:109-136; 1918.

NOWELL, W., and WILLIAMS, C. B. Sugar-cane Blight in Trinidad: A Summary of Conclusions. Bull. Dept. Agric. Trinidad and Tobago, Port of Spain, XIX, part 1, pp. 8-10. Summary in Review of Applied Ent., vol. VIII, ser. A, part 12, p. 531; 1920.

OSBORN, HERBERT. Studies of Life Histories of Froghoppers of Maine. Maine Agric. Exp. Sta. Crono. Bull., 254:265-288; 1916.

POPENOE. Contribution to a knowledge of the Hemiptera Fauna of Kansas. Tr. Kan. Ac., IX:62-64; 1886.

READIO, P. A. The Ovipositors of Cicadellidæ. Kan. Univ. Sci. Bull., vol. XIV; 1923.

RORER, JAMES BIRCH. The Green Muscardine of Froghoppers. Reprinted from Proc. Agric. Soc. of Trinidad and Tobago, 10:467-482.

SAY, THOMAS. The Complete Writings of Thomas Say of Entomology of North America.

SNODGRASS, ROBERT EVANS. The Thorax of Insects and the Articulation of the Wings. Proc. U. S. Nat. Mus., vol. XXXVI, No. 1687:511-596; 1909.

SNODGRASS, ROBERT EVANS. Seventeen-year Locust. From Smith. Report for 1919, pp. 381-409; 1921.

SMITH, JOHN B. The Structure of the Hemipterous Mouth. Science, vol. 19, No. 478; 1892.

STAL, C. Hemip. Fabriciana, IV:54; 1869.

SULC, KAREL. Respiration, Tracheensystem und Schaumproduktion der Schaumcikaden Larvæ Aphrophorinæ Homoptera. Zs. Wiss. Zoöl., 99:147-188; 1910.

TAYLOR, LELAND H. Thoracic Sclerites of Hemiptera. Ann. Ent. Soc. Amer., 11:225-249; 1918.

UHLER, P. H. Special Descriptive Account of *Rhynchota*. Rept. U. S. Geol. Surv., 3:355-475 and 765-801; 1877.

URICH, F. W. Froghoppers in Sugar Cane. Reprint from Bull. Dept. Agric. Trinidad, pp. 4-9; 1910.

URICH, F. W. Sugar-cane Froghopper and Biological Notes on Some Cercopids of Trinidad. Board Agric. Trinidad and Tobago, Circular No. 9:1-45; 1913.

URICH, F. W. Rearing the Vermillon Froghopper Egg Parasite. Board of Agric. Trinidad and Tobago, Circ. No. 7, March, pp. 1-7. Summary Rev. of App. Ent., vol. I, ser. A, part 4:116; 1913.

UHLER, P. R. Checklist of Hemiptera and Heteroptera; 1886.

VAN DUZEE, E. P. Hemiptera from Muskoka Lake District of Canada. Canad. Ent., 21:8; 1889.

VAN DUZEE, E. P. List of Insects Described by Say. Psyche, 5:388; 1890.

VAN DUZEE, E. P. Synoptic Table. Trans. Am. Ent. Soc., 19:296; 1892.

VAN DUZEE, E. P. Twentieth Rept. N. Y. St. Ent., p. 553; 1905.

VAN DUZEE, E. P. Notes on Hemiptera Taken by W. J. Palmer Near Lake Temagami, Ont.; 1906.

VAN DUZEE, E. P. List of Hemiptera Taken by W. J. Palmer About Quinze Lake. Canad. Ent., 40:115; 1908.

VAN DUZEE, E. P. Synonomy of Provancher Collection. Canad. Ent., 44:327; 1912.

VAN DUZEE, E. P. Catalogue of Hemiptera of North America; 1917.

WALKER, E. N. The Terminal Abdominal Structures of Orthopteroid Insects: A Phylogenetic Study. Annals Ent. Soc. Amer., part I, vol. 12, No. 4: 267-314; 1919. Part II, vol. 15, No. 1:1-67; 1922.

WILLIAMS, C. P. Report of the Froghopper Blight of Sugar Cane in Trinidad, No. 1; Jan. 1921. Summary in Review of App. Ento., vol. IX, ser. A, part V, pp. 201-264.

WILLIAMS, C. P. Habits of *Tomaspis tristis.* Bull. Ent. Res., vol. VII, p. 271; 1917.

WILLIAMS, C. P. Froghopper Damaging Cacao in Panama. Bull. Ent. Res., vol. XIII, part 3, pp. 271-274; 1923.

PLATE LIV.

1. Egg.
2. First instar.
3. Second instar.
4. Fifth instar.
5. Third instar.
6. Fourth instar.

PLATE LIV

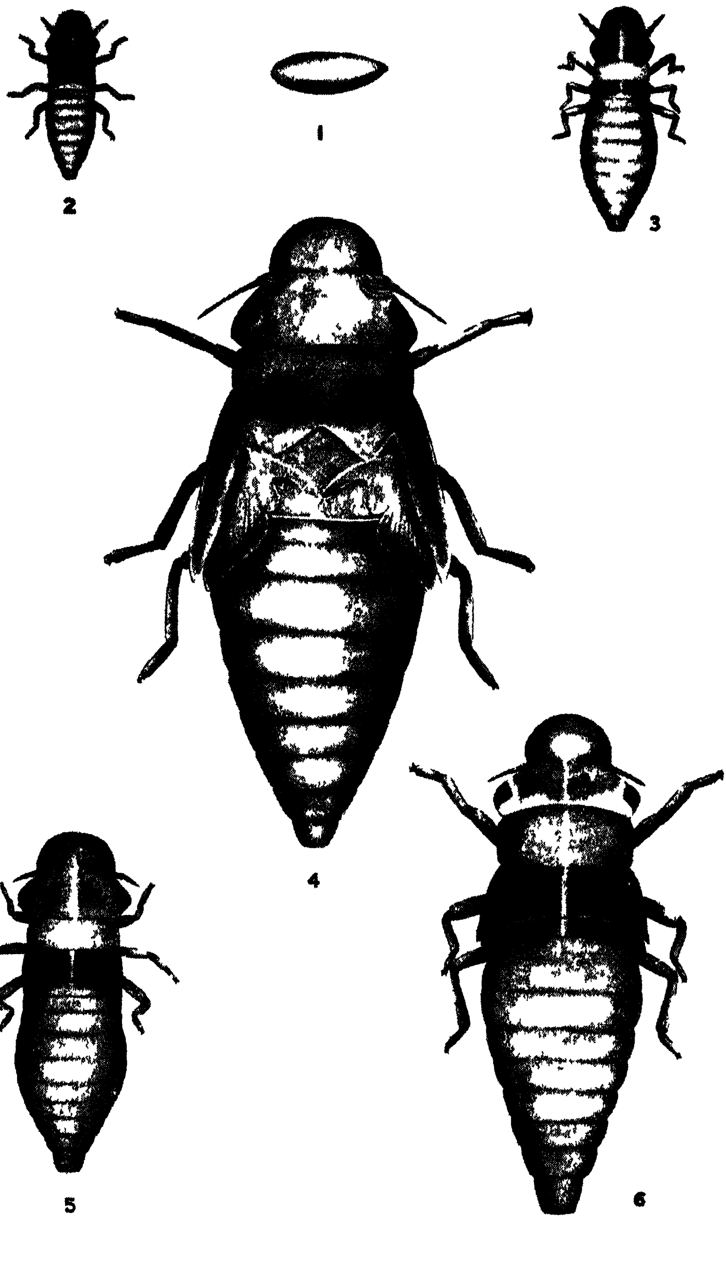
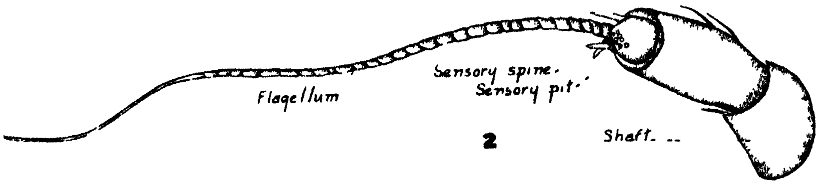


PLATE LV.

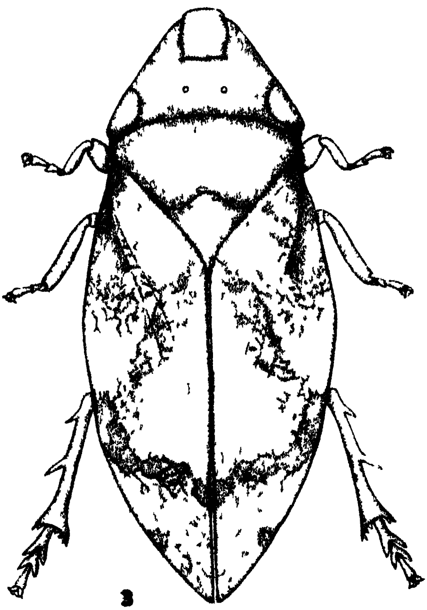
1. Lateral view of adult
2. Antenna, highly magnified
3. Dorsal view of adult.
4. Ventral view of adult.

PLATE LV.

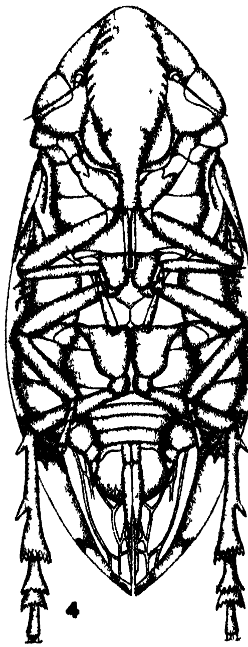
1



2



3



4

PLATE LVI.

1. Dorsal view of head.
2. Ventral view of head.
3. Dorsal view of head with vertex removed, showing the tentorium.
4. Tips of mandible and maxilla, highly magnified.
5. Lateral view of head.
6. Lateral view of thorax.
7. Dorsal view of mesothorax and metathorax.
8. Ventral view of mesothorax and metathorax.

PLATE LVI.

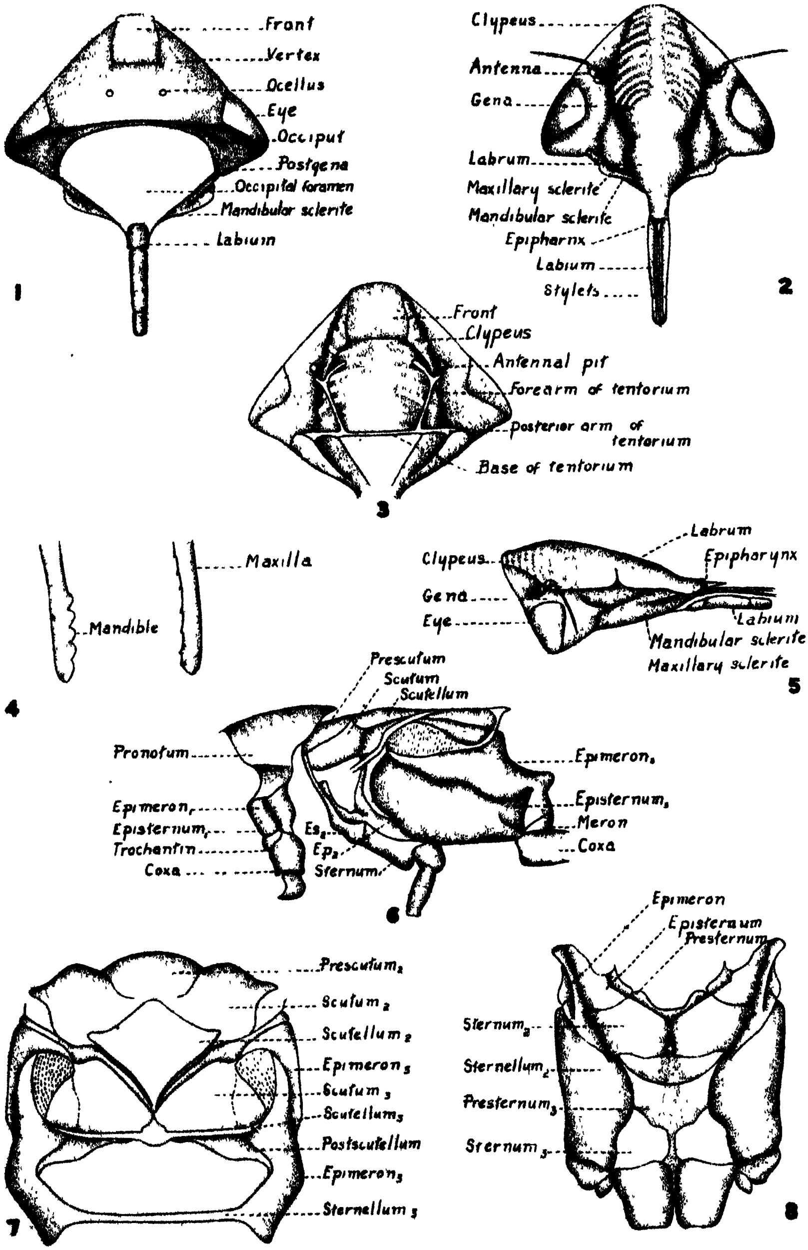

Front
Vertex
Ocellus
Eye
Occiput
Postgena
Occipital foramen
Mandibular sclerite
Labium
1
Clypeus
Antenna
Gena
Labrum
Maxillary sclerite
Mandibular sclerite
Epipharnx
Labium
Stylets
2
Front
Clypeus
Antennal pit
Forearm of tentorium
Posterior arm of tentorium
Base of tentorium
3
Maxilla
Mandible
4
Labrum
Clypeus
Epipharynx
Gena
Eye
Labium
Mandibular sclerite
Maxillary sclerite
5
Prescutum
Scutum
Scutellum
Pronotum
Epimeron₁
Episternum₁
Trochantin
Coxa
Es₂
Ep₂
Sternum
Epimeron₃
Episternum₃
Meron
Coxa
6
Prescutum₂
Scutum₂
Scutellum₂
Epimeron₂
Scutum₃
Scutellum₃
Postscutellum
Epimeron₃
Sternellum₃
7
Epimeron
Episternum
Presternum
Sternum₂
Sternellum₂
Presternum₃
Sternum₃
8

PLATE LVII.

1. Dorsal view of pronotum.
2. Ventral view of prothorax.
3. Lateral view of prothorax.
4. Caudal view of prothorax.
5. Cephalic view of prothorax.
6. Lateral view of mesothorax.
7. Dorsal view of mesothorax, showing wing attachments.
8. Lateral view of metathorax.
9. Dorsal view of metathorax.
10. Ventral view of mesothorax.
11. Ventral view of metathorax.

PLATE LVII.

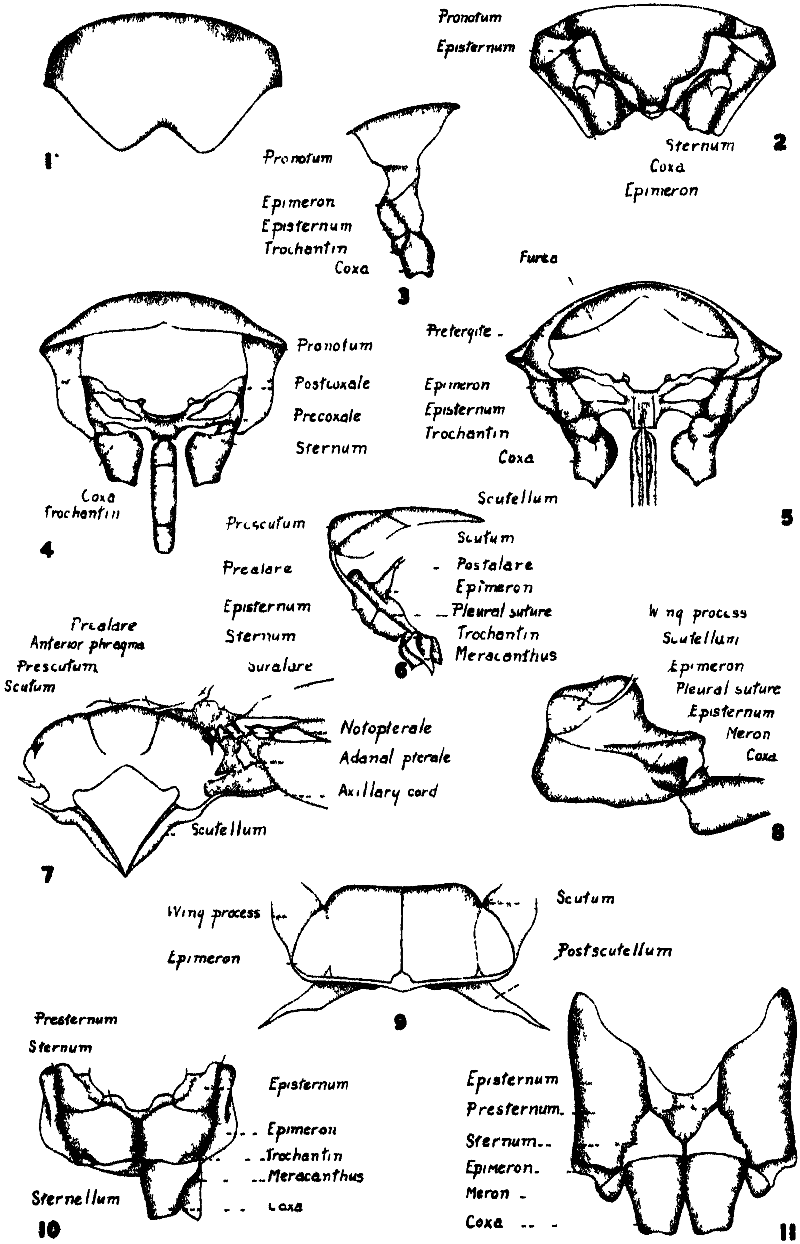

1
Pronotum
Episternum
Sternum
Coxa
Epimeron
2
Pronotum
Epimeron
Episternum
Trochantin
Coxa
3
Furca
Pronotum
Postcoxale
Precoxale
Sternum
Coxa
Trochantin
4
Pretergite
Epimeron
Episternum
Trochantin
Coxa
Scutellum
5
Prescutum
Prealare
Episternum
Sternum
Suralare
Scutum
Postalare
Epimeron
Pleural suture
Trochantin
Meracanthus
6
Prealare
Anterior phragma
Prescutum
Scutum
Notopterale
Adanal pterale
Axillary cord
Scutellum
7
Wing process
Scutellum
Epimeron
Pleural suture
Episternum
Meron
Coxa
8
Wing process
Epimeron
Scutum
Postscutellum
9
Presternum
Sternum
Episternum
Epimeron
Trochantin
Meracanthus
Coxa
Sternellum
10
Episternum
Presternum
Sternum
Epimeron
Meron
Coxa
11

PLATE LVIII.

1. Forewing, showing venation.
2. Mesothoracic leg.
3. Fore leg.
4. Fore wing, showing color pattern.
5. Hind wing.
6. Dorsal view of tarsal claws.
7. Hind femur, showing flaplike process.
8. Metathoracic leg.
9. Ventral view of tarsal claws.

PLATE LVIII.

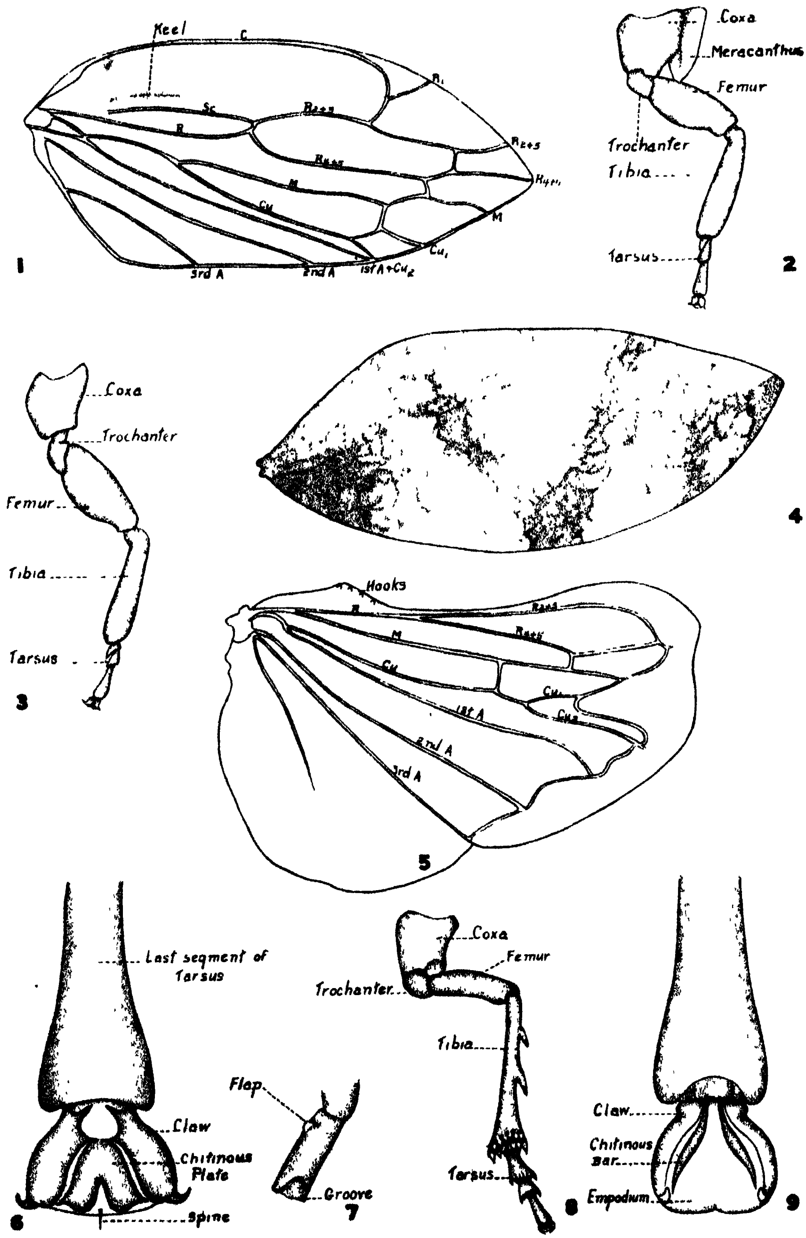
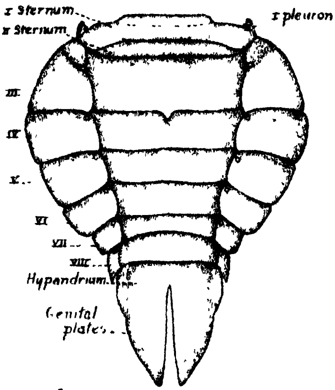

Keel
C
Sc
R
R1
R2+3
R2+3
R4+5
R4+5
M
Cu
M
Cu1
3rd A
2nd A
1st A+Cu2
1
Coxa
Meracanthus
Femur
Trochanter
Tibia
Tarsus
2
Coxa
Trochanter
Femur
Tibia
Tarsus
3
4
Hooks
R
R4+5
R4+5
M
Cu
Cu1
Cu2
1st A
2nd A
3rd A
5
Last segment of
Tarsus
Claw
Chitinous
Plate
Spine
6
Flap
Groove
7
Coxa
Femur
Trochanter
Tibia
Tarsus
8
Claw
Chitinous
Bar
Empodium
9

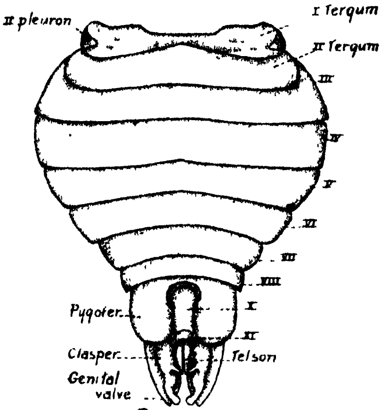
PLATE LIX.

1. Ventral view of male abdomen.
2. Dorsal view of male abdomen.
3. Lateral view of male abdomen.
4. Lateral view of female abdomen.
5. Dorsal view of female abdomen.
6. Ventral view of female abdomen.

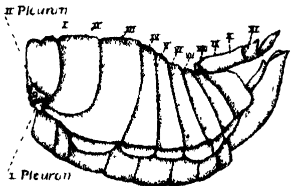
PLATE LIX.



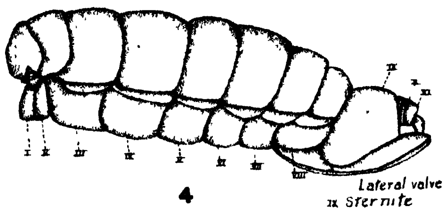
1



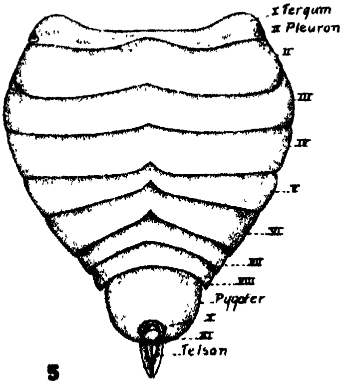
2



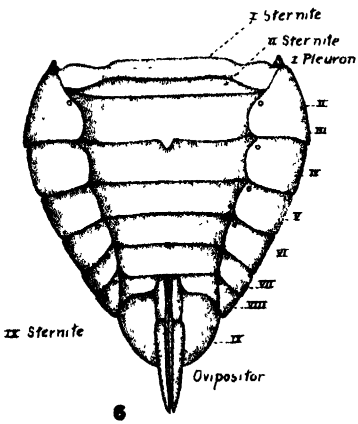
3



4



5



6

PLATE LX.

1. Ventral view of female genitalia.
2. Lateral view of ventral valve.
3. Lateral view of lateral valve.
4. Rodlike structure found on ventral valve.
5. Ventral view of dorsal valves and lateral valve.
6. Dorsal view of female genitalia.

PLATE LX.

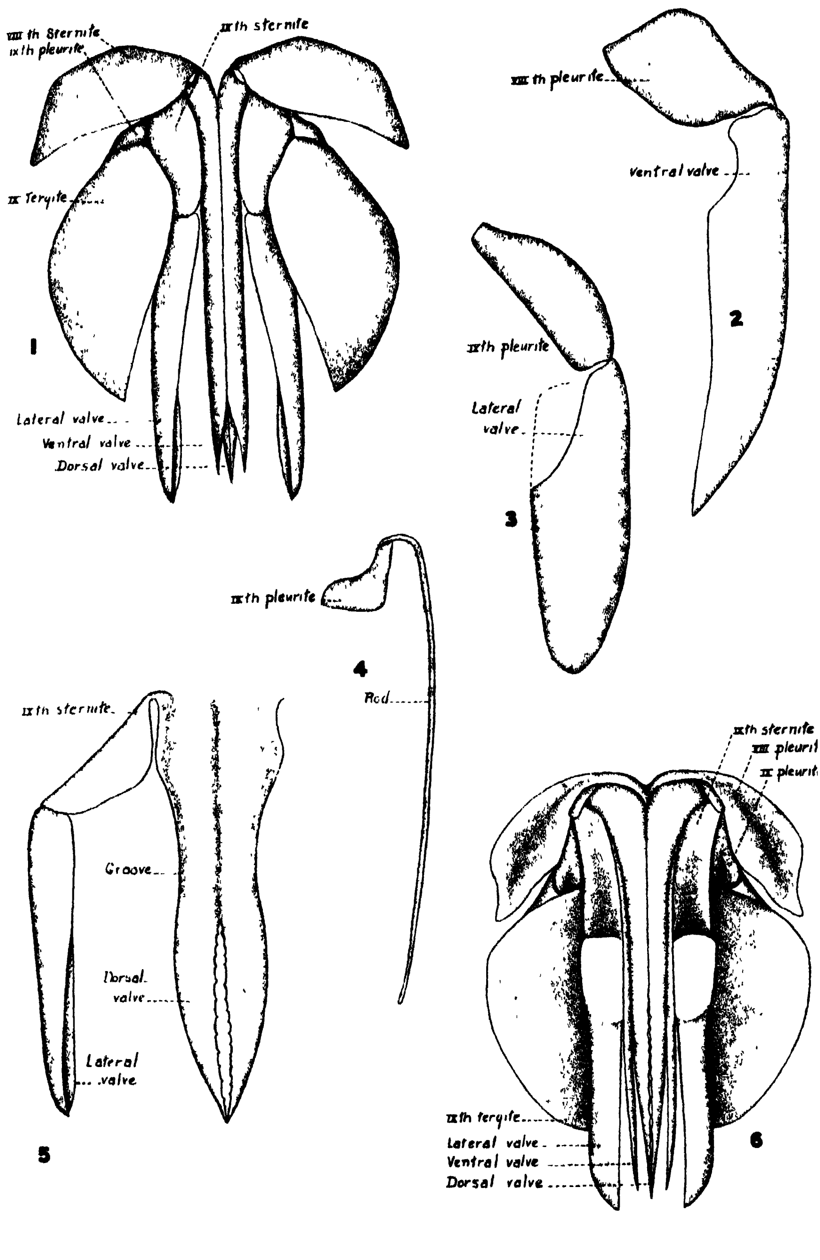

VIII th Sternite
IXth pleurite
IXth sternite
IX Tergite
1
Lateral valve
Ventral valve
Dorsal valve
VIII th pleurite
Ventral valve
2
IXth pleurite
Lateral valve
3
IXth pleurite
4
Rod
IXth sternite
Groove
Dorsal valve
Lateral valve
5
IXth sternite
VIII pleurit
IX pleurit
IXth tergite
Lateral valve
Ventral valve
Dorsal valve
6

PLATE LXI.

1. Ventral view of the last three abdominal segments in first-instar male.
2. Ventral view of last three abdominal segments of second-instar male.
3. Ventral view of last three abdominal segments of third-instar male.
4. Ventral view of last three abdominal segments of fourth-instar male.
5. Lateral view of adult male genitalia.
6. Ventral view of last three abdominal segments of fifth-instar male.
7. Ventral view of adult male genitalia.
8. Dorsal view of adult male genitalia.

PLATE LXI.

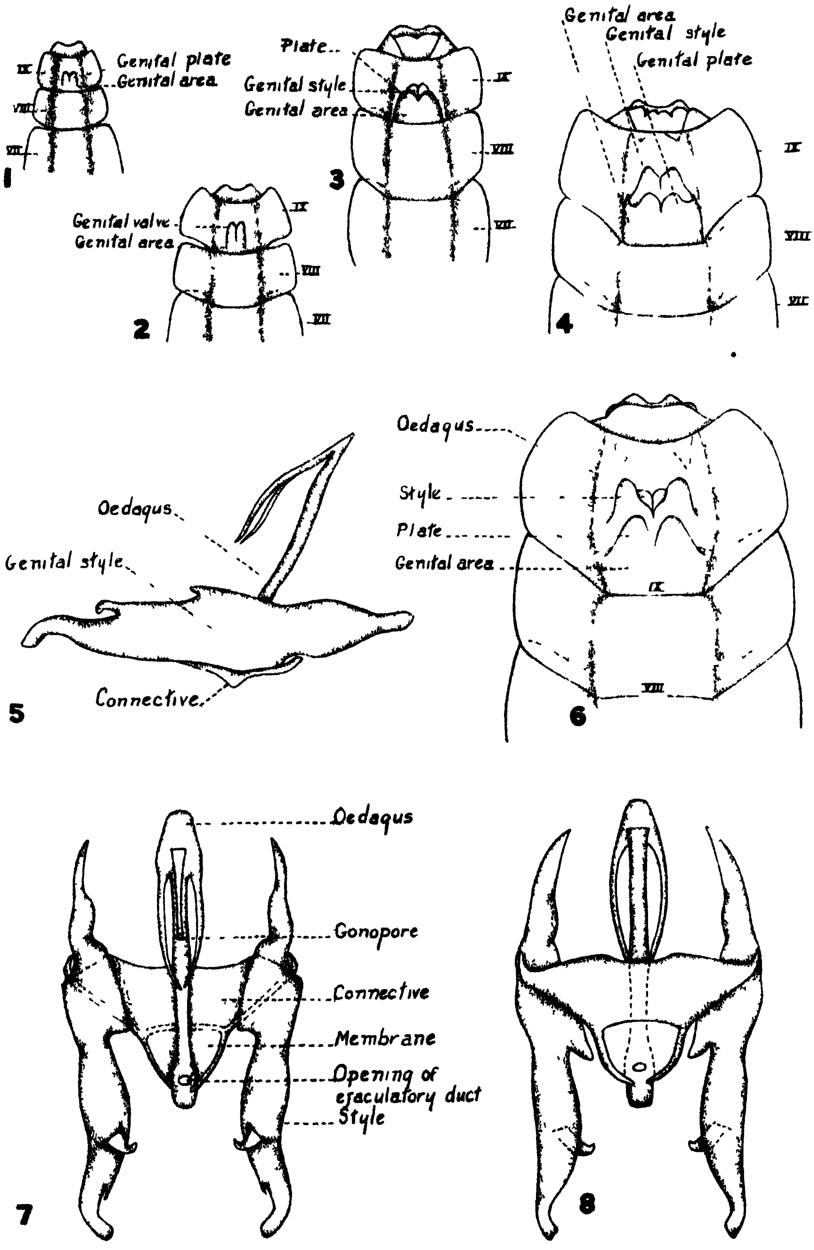
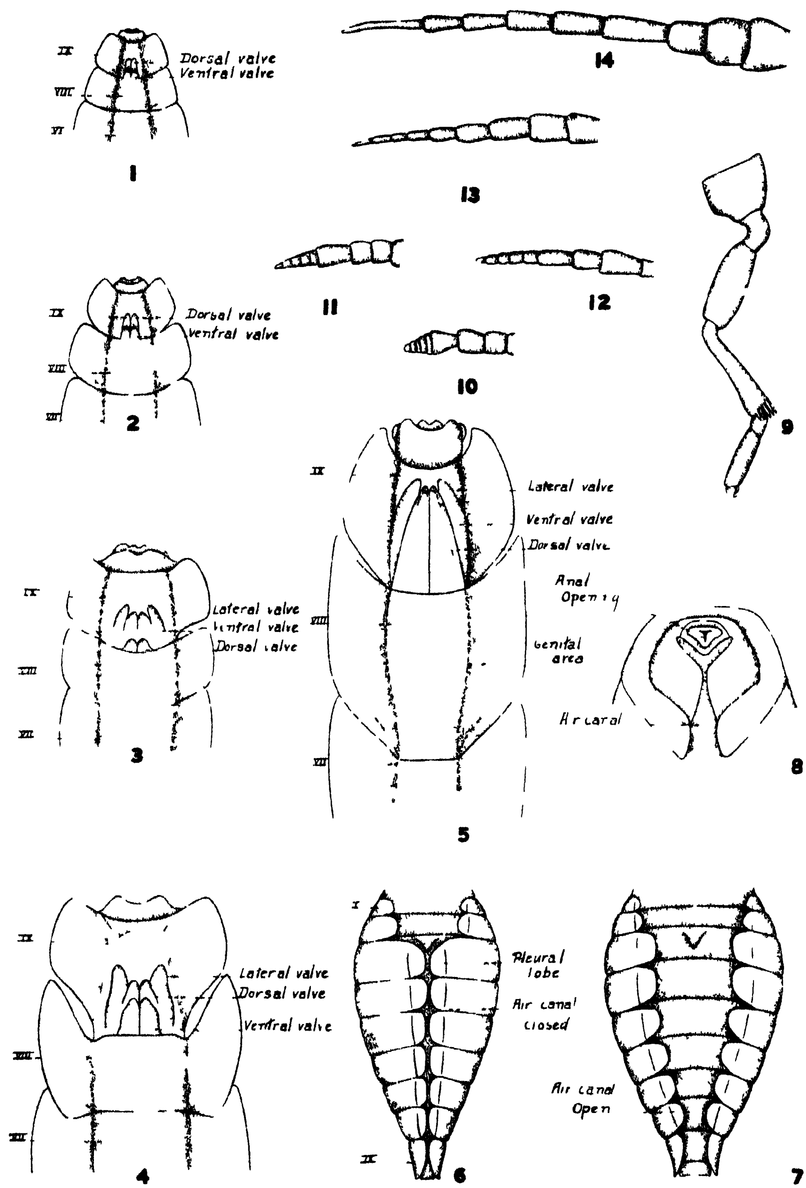

Genital plate
Genital area
IX
VIII
VII
1
Genital valve
Genital area
IX
VIII
VII
2
Plate
Genital style
Genital area
IX
VIII
VII
3
Genital area
Genital style
Genital plate
IX
VIII
VII
4
Oedagus
Genital style
Connective
5
Oedagus
Style
Plate
Genital area
IX
VIII
6
Oedagus
Gonopore
Connective
Membrane
Opening of ejaculatory duct
Style
7
8

PLATE LXII.

1. Ventral view of last three abdominal segments of the first-instar male.
2. Ventral view of last three abdominal segments of the second-instar female.
3. Ventral view of last three abdominal segments of the third-instar female.
4. Ventral view of last three abdominal segments of the fourth-instar female.
5. Ventral view of last three abdominal segments of the fifth-instar female.
6. Ventral view of the nymphal abdomen with the air channel closed.
7. Ventral view of the nymphal abdomen with the air channel open.
8. Caudal view of the tip of the abdomen, showing anal opening.
9. Mesothoracic leg of a fifth-instar nymph, showing spines on the femur.
10. First-instar antenna.
11. Second-instar antenna.
12. Third-instar antenna.
13. Fourth-instar antenna.
14. Fifth-instar antenna.

PLATE LXII



IX
VIII
VII
Dorsal valve
Ventral valve
1
14
13
11
12
10
9
2
Lateral valve
Ventral valve
Dorsal valve
Anal Opening
Genital area
Air canal
3
5
8
4
Pleural lobe
Air canal closed
Air canal Open
6
7